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January, 1953

How two inches of steel made a yardstick

HERE is one of the busiest machines in our research laboratories. It is a *constant-pressure* test lathe that quickly provides an indication of how fast a steel can be machined.

This unique testing device consists of a standard lathe fitted with special control equipment by which the horizontal pressure on the cutting tool is kept constant during the machining operation. By actually machining a test bar on this lathe and measuring the number of revolutions necessary to advance the cutting tool exactly two inches, we obtain—in a matter of minutes—a precise record of the steel's machinability.

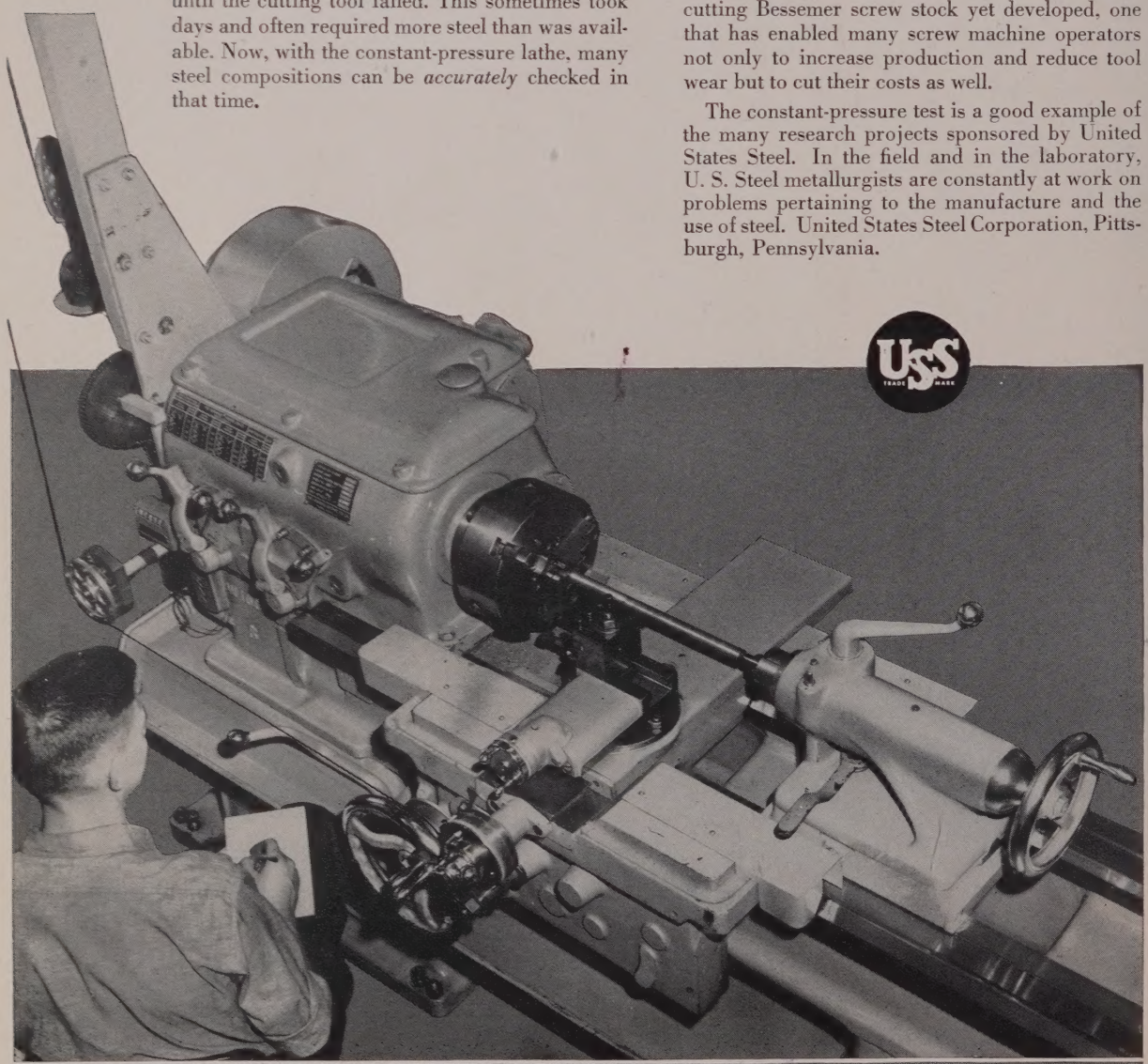
Before this development, the normal way to test machinability was to machine a sample of steel until the cutting tool failed. This sometimes took days and often required more steel than was available. Now, with the constant-pressure lathe, many steel compositions can be *accurately* checked in that time.

Typical of what this has meant to steel users is our development of MX Free-machining Bar Stock.

Bar stock is used in producing the millions of machine parts that are made on screw machines—those high-speed automatic machines that can simultaneously perform many operations such as drilling, forming, threading, chamfering and tapping at a rate of 1000 or more parts per hour. Here, machinability is of first importance, and often spells the difference between profit and loss.

So when we set out to give the screw machine industry steels that would have the utmost in machinability, we called on the constant-pressure test lathe to speed up this research. With its help, hundreds of compositions were quickly and accurately screened. The result was MX—the fastest-cutting Bessemer screw stock yet developed, one that has enabled many screw machine operators not only to increase production and reduce tool wear but to cut their costs as well.

The constant-pressure test is a good example of the many research projects sponsored by United States Steel. In the field and in the laboratory, U. S. Steel metallurgists are constantly at work on problems pertaining to the manufacture and the use of steel. United States Steel Corporation, Pittsburgh, Pennsylvania.



UNITED STATES STEEL

An Editorial . . .

The modern trend in engineering education is toward specialization. As a result of this, many studies in fine arts and literature have been expurgated from the engineering curriculum. Their place has been filled with technical subjects, but a lamentable void has been left in the engineer's education.

He is undoubtedly well versed in the use of the slide rule, the handbook, and the formula; has he ever heard of Nijinski, Ponselle, or Mann? By virtue of his technical skills he is well-fitted to take his place in industry; what skills has he acquired to enable him to take a place in society?

He has been deprived of an extremely valuable part of his education, the study of fine arts and literature. The personal satisfaction so easily derived from an appreciation of art, music, and literature; the diversity of interests, the wide variety of conversational topics; and, so necessary to advancement in the business and social world, the ability to get along with persons of all types; all of these have been snatched from the engineer in the mad rush for technical training.

This situation could be readily remedied. Through a judicious choice of subjects, a truly liberal education could be gained without the expenditure of an excessive amount of time. A few hours spent in the study of "Music Appreciation," "Great Literature of the World," and "Ethics, Logic, and Psychology" would open doors to new fields of interest to the student; doors that were formerly not only locked, but of which the student was unaware.

The courses required in such a program would probably not be courses that are being taught at the present, but would have to be arranged so as to fulfill the goals of the new curriculum. These goals would be: the fostering of a true appreciation of different art forms such as music, through the building of a foundation which, with the student's further experience, would lead to this appreciation; and the understanding of basic human psychology and ethics.

The hours spent in such a course of study would be repaid many times, in many ways. The intrinsic worth of the benefits to be derived from this curriculum cannot be readily evaluated, the wider range of interests, the increased conversational adeptness so easily acquired with the foundation of a well rounded education; are hard to assign a definite value. The most benefit that the student would get from this course of study would be the personal satisfaction and enjoyment that could be derived from a sincere appreciation of the fine arts and literature. New horizons of enjoyment and unlimited possibilities of recreation would be opened to him.

RICHARD L. SYDNOR

to the

ELECTRICAL ENGINEER

or

PHYSICIST

with an interest in

RADAR

or

ELECTRONICS

Hughes Research and Development Laboratories, one of the nation's leading electronics organizations, are now creating a number of new openings in an important phase of their operation.

Here is what one of these positions offers you:

THE COMPANY

Hughes Research and Development Laboratories, located in Southern California, are presently engaged in the development and production of advanced radar systems, electronic computers and guided missiles.

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The positions are for men who will serve as technical advisors to government agencies and companies purchasing Hughes equipment—also as technical consultants with engineers of other companies working on associated equipment. Your specific job would be essentially to help insure successful operation of Hughes equipment in the field.

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In one of these positions you will gain all-around experience that will increase your value to our organization as it further expands in the field of electronics. The next few years are certain to see large-scale commercial employment of electronic systems. Your training in and familiarity with the most advanced electronic techniques now will qualify you for even more important future positions.

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See your Placement Office for appointment with members of our Engineering Staff who will visit your campus. Or address your resumé to the Laboratories.

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volume 68 **number 4**

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our cover

Today's metallurgists are working overtime to develop new alloys to meet the demands of increased speeds, temperatures and pressures found in the machines and vehicles of the atomic age. The cover shows a workman pouring a test specimen for tensile and metallurgical tests against a background of a 100X photomicrograph of the crystalline structure of grey cast iron. Photomicrographs such as the one shown are useful in analyzing metals and alloys. (Photomicrograph courtesy U. of I. Metallurgical Engineering Laboratory).

our frontispiece

A giant power shovel removes the overburden from a central Illinois strip mine. In mining operations, a large number of specialized machines are used such as the power shovel, the continuous miner and the conveyor. Many of these machines have been developed in recent years making the age-old mining industry as modern as today's progressive mining engineers' accomplishments. (Photo courtesy Illinois State Geological Survey)

MARION
LITTLE SISTER COAL CORPORATION
MARION
5561

faster coal mining by the . . .

Joy Continuous Miner

by Paul E. LaViolette, E. E. '56

On December 14, 1948, the Joy Manufacturing Company came out with another one of its many "firsts" in coal mining — the first practical single-operation coal mining machine capable of being commercially produced.

The Joy Continuous Miner, as it was named, does in one quick operation what has been formerly an expensive, time-consuming, and dangerous process. Instead of drilling, cutting, and blasting, the J.C.M. unit literally rips coal loose from the seam face at the rate of 130 tons per shift. The mined coal, washed down and in manageable chunks, is then carried on internal conveyors to the rear of the machine to be loaded onto mobile conveyer units.

The Joy Continuous Miner is the result of eight years' intensive research by the engineers of the Joy Company. They have not been alone, however, for every mining machinery maker has been working on one. Bituminous Coal Research, Inc., allocated $250,000 for the development of a similar mining and loading machine. Several companies were able to make models, but were unable to work out production difficulties. Today there are more than one hundred fifty Joy Continuous Miners in operation with more on order.

The machine comes in two heights: thirty-four inches for low seam mining and forty-five for high seam. It is slightly more than twenty-five feet long by seven and one half feet wide. The J.C.M. is composed of three parts: (1) a ripper bar unit consisting of a rotary drum type head fitted with carbide bits and dampening hoses; (2) main chassis with controls, power and intermediate conveyer; and (3) a rear conveyer unit. The ripper bar unit is fitted with a rotary drum head, an innovation which is far superior to the older type side cutters. It needs less power and bits and is capable of a larger percentage of chunk size over one inch. The ripping itself is basically as follows: the machine is advanced to the coal face and the ripper bar lowered to the base of the seam. Here it is advanced eighteen inches horizontally into the coal by hydraulic pressure. This advance in the coal seam is known as "sumping." The ripper bar is then forced up through the coal seam by hydraulic pressure. The rotary drum action rips the carbide teeth free of the coal seam bringing with them large chunks of the coal to be conveyed to the central hopper. Other teeth replace the ones removed and the ripper bar is forced to the top of the seam. On reaching the top, the bar is again lowered, the machine crawls forward the eighteen inches gained, and the process is repeated.

All coal that falls down from the head in front of the unit is scooped up in a chute directly behind the ripper bar unit. This, too, is hydraulically raised and lowered.

The whole ripper bar unit can be trained in an arc of forty-five degrees. This enables the continuous miner to turn from a twelve foot mine entry into a twelve foot room at ninety degree angle. The bar can also be depressed five and one half inches below the base and elevated sixty-six inches above it; allowing full maneuverability in following the seam especially when there are noticeable bottom rolls.

All power motors are assembled on the main chassis. Power is supplied to the rotary drum on the ripper head unit by two sixty-five continuous horsepower motors giving to the unit a total of one hundred thirty horsepower available at all times. Hydraulic pressure is maintained by a fifteen-gallon per minute gear pump driven by a seven and one-half horsepower motor. All electrical equipment is kept to a minimum and all of it is explosion proof. The power supply is remote; connected to the continuous miner by a cable connected to the rear of the main chassis.

The operator controls are on the right hand side of the main chassis, fourteen feet from the ripper head thus allowing the operator to remain under

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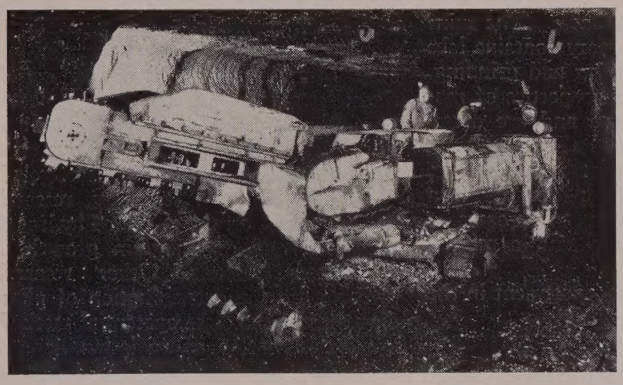
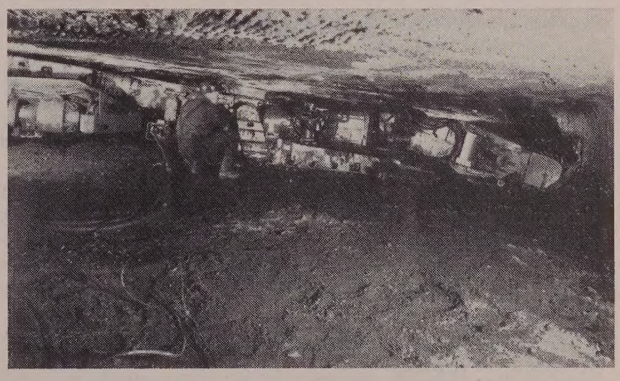
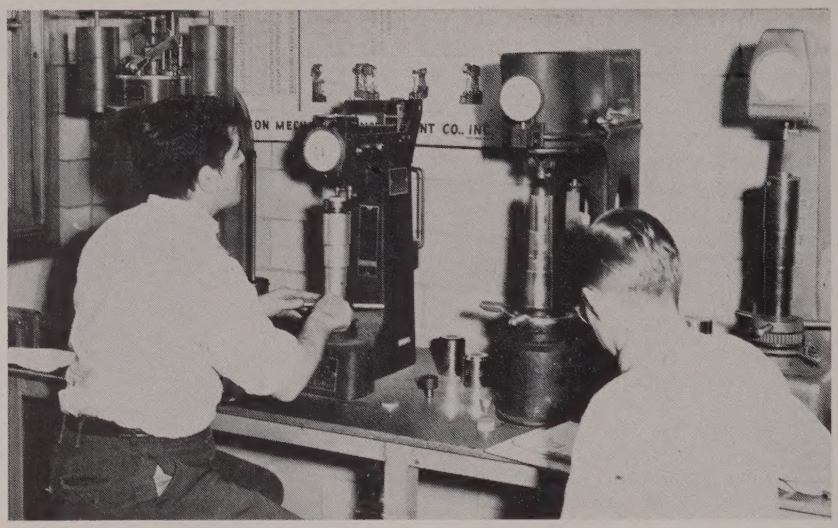




Left: Working a "room" with the continuous miner. Operator, well clear of cutting head, controls machine operation with levers. Right: A low seam Joy Continuous Miner ideally suited for working seams of 40 to 60 inches thickness, about to "sump" a pillar. (Courtesy of Joy Manufacturing Company.)



Testing hardness of metals by measuring the depth to which an indentation is pressed into the surface.

The Technograph features the . . .

The material foundations of our modern society depend, to a large extent, on a continuous supply of large quantities of minerals and metals. An organization which does much to insure that this ample supply will continue is the Mining and Metallurgical Engineering department here at Illinois. Although the fields of mining and metallurgy are both centuries old, the rapid developments in these fields during the last two decades have put the fields of mining and metallurgy a t the frontiers of engineering. These frontiers are being explored and new areas are being discovered here at Illinois.

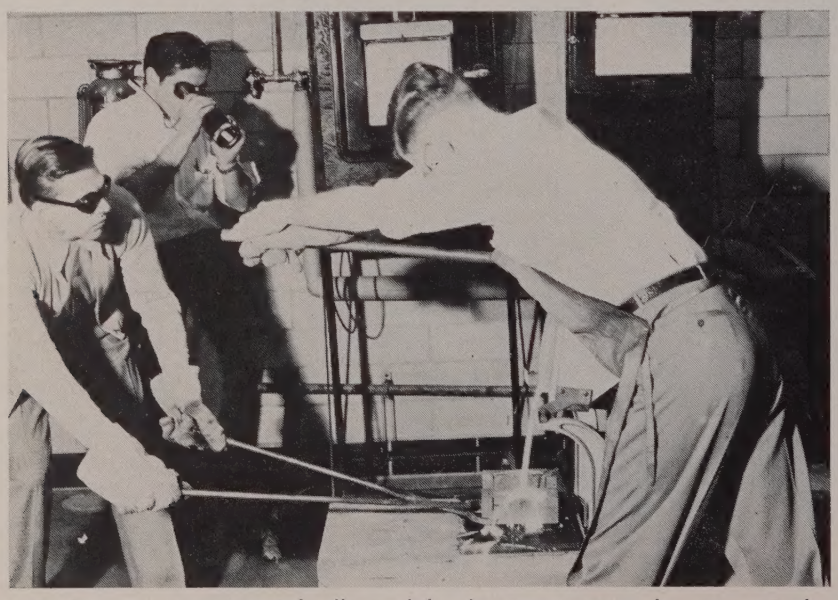
The teaching and research activities of the mining and metallurgical engineering department are conducted mainly in the metallurgical engineering laboratory, the mining engineering laboratory, and the ceramics building. The Met lab houses the metallographic, electro-metallurgical, and heat treat laboratories. It also has laboratories for the study of physical and mechanical testing, fuels, and furnaces. The mining engineering laboratory contains labs for the study of sampling and grinding, chemical and physical properties of materials, coal preparation and ore dressing, and ventilation. In the ceramics building are the departmental offices, x-ray diffraction units, mine models, a museum, a design room, classrooms, a departmental file room, and a mining instrument room.

No description of a department in the college of engineering is complete without some mention of research, which is such a vital function of engineering. The department does research in three areas of mining. In the field of mine ventilation, electrical and anemometric gauges for the measurement of the flow of air in closed ducts have been developed. Research has also been done in the field of explosives, with the blasting effects of commercial explosives being investigated to determine the useful energy formed under controlled conditions. Research has also been done on physical properties of m i n e r a l s and rocks. Hardness, strength, and various elastic properties have been investigated.

In the field of metallurgy, research has been done on the effect of hydrogen in welds, and on subgrain growth in cold-worked metals. Other research projects are the determination of phase diagrams by the electropotential method, the determination of radiation damage in metals, and the study of a special phase, occuring in various binary and ternary alloys, called the sigma phase. Finally, work is being done in investigating the internal friction in metals.

The history of the mining and metallurgical engineering department dates back to the beginnings of the University of Illinois. The initial report of the Committee on Course of Study and Faculty provided for courses in mechanical science and art, civil engineering, mining engineering and metallurgy, and architecture. . . . In spite of these early plans, mining engineering education was slow in catching on. Up to 1885, the department never had more than six students in any one year, and the total number of graduates since 1867 was six. The curriculum in mining engineering was discontinued in 1889. It started up in 1891, but was discontinued again in 1893.

In 1907, W. F. M. Goss was appointed Dean of the College of Engi-



Casting an experimental alloy while the temperature by an optical pyrometer.

Mining and Metallurgical Engineering Department

by Bob Schrader, Chem. E. '54

neering. Dean Goss was eager to have the department of mining engineering reestablished. The new department was started in the fall of 1909, with Harry Harkness Stark, then editor of the technical magazine, *Mines and Minerals*, appointed head of the department. Professor Stark continued as head of the department until his sudden death in 1923. Professor H. L. Walker, present head of the department, has said of Stark, "Dr. Stark's vision, enthusiasm, and technical ability were responsible for the development of the curriculum, the construction and equipment of a fine mining laboratory, the securing of a competent teaching staff, and the maintenance of the highest standards of technical instruction."

Until the fall of 1912, the offices and classrooms of the Mining Department were scattered all over campus. That fall the mining department moved into the second floor of the then new Transportation building. Departmental and staff offices, class rooms, drafting rooms, and the museum were housed in the transportation building until 1941, when the department moved to its present location in the ceramics building. Also, the newly constructed mining laboratory was occupied in the fall of 1912.

An option in metallurgy was first offered in 1916. The metallurgical option was elected in the senior year and consisted of courses in process metallurgy, mineral dressing, and metallurgical design. This option was continued until 1934, when a curriculum in metallurgical engineering was offered. By 1935, the name of the department had been officially changed to the department of mining and metallurgical engineering, and the first degree in metallurgy achieved its full prominence in 1937, when the metallurgy lab was completed. This laboratory consisted of an east addition to the mining laboratory.

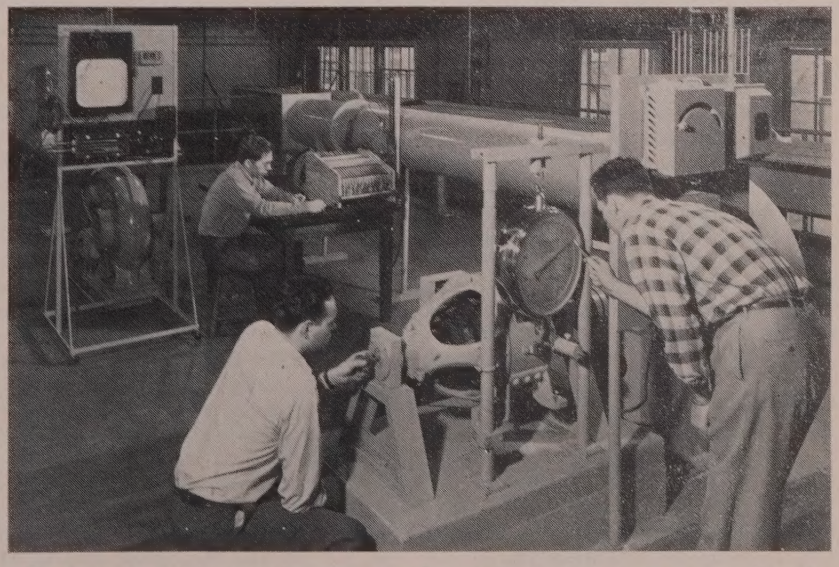
Metallurgy is divided into three main divisions: chemical, physical and mechanical metallurgy. Chemical metallurgy is concerned with methods used to produce and refine metals from their ores. The chemical metallurgist attempts to design methods for more efficiently winning metals from their ores, to get rid of impurities in the ore, to develop refining techniques, to study the rate and mechanism of reactions at high temperature, to develop better refactory materials, and to improve general production procedures.

Physical metallurgy deals with the nature, structure, and physical and mechanical properties of metals and alloys. The physical metallurgist studies the nature and internal structure of metals and alloys, their chemical, physical, and mechanical properties, their heat treatment, and the methods of testing, commercial uses, defects, and design of new alloys for special purposes.

Mechanical metallurgy includes all the processes of working and shaping metals, such as rolling, forging, spinning, and casting. The mechanical properties of metals and alloys produced by the forming operations and with the proper design of equipment for accomplishing these tasks. In the foundry he is concerned with the effects of all variables of design of alloy composition, temperature of metal, molds and molding, and other techniques.

Obviously, a four year curriculum in metallurgy cannot hope to give the student a knowledge of all the diversified fields of metallurgy. The curriculum does attempt to equip the student with a firm foundation in metallurgical principles so that he can enter any industry, and to give him a sufficient

(*Continued on page* 40)



Students in mining engineering conduct an experiment on a centrifugal fan in the Ventilation Laboratory at the University of Illinois.

the Technograph tours the . . .

WHITE PINE PROJECT

by Warren H. Brandt, C. E. '54

The highest place in the State of Michigan is Government Peak in the Upper Peninsula — 2,003 feet above sea level, but the busiest place by far is within shouting distance of this prominence and that is the White Pine Copper Company's White Pine project; located in Ontonagon County, about 18 miles southwest of Ontonagon. Remarkable changes have been wrought in the stands of second growth timber that dot the foothills of the beautiful Porcupine Mountains.

The terrific wartime demand for copper has resulted in one of the greatest exploration and recovery programs to be instituted in recent years. The demand for copper is probably only exceeded by the demand for steel. As a result many old abandoned copper workings have been re-explored, and those which were formerly unprofitable have been investigated in the new light of present needs. And such is the case of the White Pine project.

Historically, Ontonagon County and copper have been intimately united since Ontonagon's first citizen—Jim Paul—recovered the fabulous copper boulder bearing his name on the banks of the Ontonagon River near the present site of the Victoria dam, in 1776. The monstrous boulder which Paul found was supposed to have weighed in excess of five tons, but its present weight at the Smithsonian Institute is three tons. The news of this boulder spread like wildfire especially after it was put on exhibition in Detroit.

Mining commenced in the Ontonagon country after the turn of the nineteenth century, but the larger developments did not get under way until 1847 when the famed Minnesota mine opened. This mine was noted for the huge dividends which were declared on its stock as a result of the high quality of the ore recovered. Work at the present site of the White Pine Mine did not get under way until 1881 when a 170 foot shaft was put down together with several other minor workings, all founded in copper bearing rock. Because of the low grade ore recovered work was discontinued in the following year.

In the early 1900's the Calumet and Hecla Copper Company became interested in the dormant White Pine property and purchased it. By means of a series of diamond drill exploratory tests they determined the extent of the workable ore body and undertook means of recovering it. Their operations were rather successful and they erected several stamp mills, crushers and associated equipment on the slopes of the Mineral River near the site of the original White Pine shaft. These workings are in ruins at the present time, but they attest the value of the original property and ore body, a portion of which is under development now.

The author, Warren H. Brandt (left), assists Bruce Graham on a computation in the White Pine field office of PACE Associates. (Photo by Edwin Urpila)

The C & H Company closed down operations at White Pine in 1921 and most of the physical plant was removed. This was the second time that the White Pine area went into a temporary seclusion due to a lack of interest in the low grade ore body.

The Copper Range Company of Boston, Massachusetts, became interested in the property in 1937. It has put down a pilot shaft — the Bill Schacht shaft, to determine the character of the main ore body, the type of recovery methods to be used, tools necessary for ore recovery and any additional information pertinent to the efficient operation of the property.

This shaft, which slopes at an angle of 30° to the horizontal and is 570 feet deep, will be a part of the main workings after present construction in the area is completed. The shaft will connect with a new shaft now being driven at right angles to it.

On the basis of the Copper Range Company's explorations it has been conclusively determined that the ore body now being tapped is of sufficient magnitude to furnish copper for the next fifty years. Some have termed it the largest body of undeveloped copper ore on the North American continent.

The ore body being worked is in the main a chalcocite, cuprous sulfide (Cu_2S) containing about 80% copper. In addition there is a small amount of native copper in the form of copper flakes of almost infintestimal size. The chalcocite with the native copper brings about 6% copper to the ton of material removed. This relatively light recovery is balanced by the extensiveness of the ore body.

On the basis of these preliminary studies the Copper Range Company was granted by the U. S. Government's Reconstruction Finance Corporation the largest peacetime loan ever made — 57 million dollars — to construct the necessary facilities to recover, process and ship the metallic copper from the White Pine site.

The Copper Range Company thereupon set up as a separate entity to operate the property, the White Pine Copper Company. The White Pine Copper Company hired the well-known Turner Construction Company as it's agent for the construction job.

The Copper Company had determined that to efficiently recover the ore, ultimately 1200 employees would be required. Immediately prospectuses were prepared to secure the necessary architectural and engineering skill for the design of a town and associated works to house these employees. Also needed were plans for the process buildings and required connective facilities such as administration buildings, garages, etc.

Selected for this monumental task was the six year old firm of PACE Associates, Chicago. PACE (stands for planners, architects, consulting engineers) was well qualified to handle this assignment on the basis of its architectural

and engineering treatment of a similar venture for the Reserve Mining Company at Beaver Bay, Minnesota.

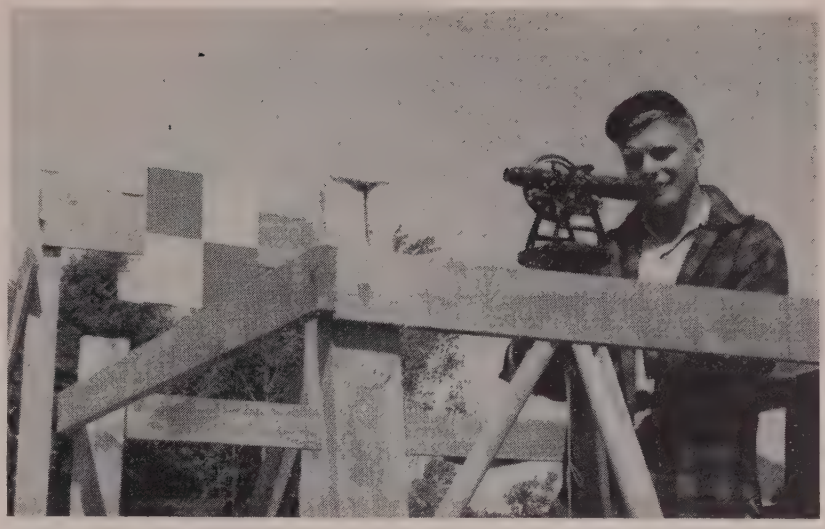
The site planning department of PACE set about at once to lay out the streets and homes for the White Pine Copper Company employees. PACE has in its employ a sociologist to guide the site planners in the layout so that the neighborhood ills so common to the older American towns and cities would be avoided in the pioneering effort of White Pine. The curved street layout, the judicious treatment of parking and shopping centers, exhibits dramatically the sociological viewpoint of keeping these important items in the forefront of intelligent planning and design. With beautifully landscaped residential areas, well designed stores and schools, the White Pine town should be a model for all future city planners to point to with pride.

The original surveys for the White Pine townsite were under way in March, 1952. Required was a complete topographic map of an area about two and one-half miles square. This region is heavily wooded and swampy, making any kind of survey work difficult. Nevertheless the surveys proceeded and as soon as the first topographic sheets were available the architects together with the city planners prepared drawings for the first buildings in the townsite. These are a hospital, four dormitories, a boiler house, service building housing the cafeteria and a staff dormitory. These buildings were commenced in May, 1952, and are practically complete.

As soon as surveys were available in the White Pine works area architectural plans were prepared for the important buildings to be used for processing the ore and for related services. PACE Associates have prepared plans and supervised the construction of a works administration building, a warehouse and machine shop and a mine change house. The other process buildings are under design by another engineering firm to take advantage of their familiarity with the chemical and metallurgical processes of treating copper ore.

In the late summer of 1952 plans for a school and a shopping center were being prepared, rounding out the entire White Pine townsite with as many facilities benefitting the community as possible.

The entire White Pine mining arrangement is unique in that a minimum of handling of the copper bearing rock is required. The initial processing of the ore will be done underground. In contrast to the usual methods of transporting the rock from the mine to the smelter, that of using small cars and an elevator in a shaft, the White Pine mine will use conveyor belts. These belts will carry the ore directly from the working face to the process area underground. The initial crushing is carried out in a plant near the present pilot shaft. As mentioned before, all this work is done underground with the gangue, or waste rock, being returned to the mine for disposal subsurface.



Donald Heikkinen, PACE Associates instrument man, sets his transit up over a survey station in the White Pine townsite. The signal on the left is for sighting from distant stations.

At present a huge portal is under excavation adjacent to the works area. This portal leads on a gentle slope into the pilot shaft and will utilize the pilot shaft as an integral part of the mining operations. This tremendous excavation is 250 feet wide and 1000 feet long. It grades from ground level at the works area end to a depth of eighty feet at the pilot shaft end. The crushing plant will be located in this portal slope and will subsequently be covered with earth. Excavating the portal requires some of the largest earth-moving equipment ever to see the Upper Peninsula and was pursued throughout the summer months on a twenty-four hour a day schedule.

Considerable quantities of water are required for processing the copper ore. Originally plans called for the construction of a dam on the Iron River, one and one-half miles distant from the works area. This plan was abandoned when it was determined that the volume of water in the river in some of the dry summer months might not be sufficient to operate the plant. It was decided then to construct a water tunnel into Lake Superior six miles north of the White Pine townsite. The intake is to be located about 2000 feet out in the Lake where potable water is available. The expense of constructing this tunnel will be more than offset by the wealth of geological information secured in driving through the underlying rock formations.

All buildings in the works area are of reinforced concrete construction or steel and brick construction for permanence. They are of course as modern as the far-seeing architect can make them.

In addition to the works area and the townsite there is a trailer camp which will house families utilizing that means of dwelling. It is completely modern, having full water and sewage facilities together with a service building for each block of trailers to provide the necessary accommodations for bathing, washing clothes, etc. The presence of this trailer area has attracted many persons who like that means of commuting and has enhanced the position of the trailer in the travel- and transport world.

The townsite is of course, the most important area as far as the worker is concerned and no expense has been spared to make the surroundings as comfortable as possible. The engineers have laid out most of the ten miles of curved and winding roadways and some of the 940 dwelling units. The streets are to be a hard surface with curb and gutter. They are mostly on gentle grades giving the visitor an impression of being in a rather hilly region. Actually the townsite is located on a narrow plateau between two river valleys —the Mineral and the Iron. While the townsite is not free to expand in an east-west direction it has unlimited room for expansion in a southerly direction and this feature was important in the selection of the particular site used. The dwellings likewise are located

(*Continued on page* 44)

introducing . . .

by Roger L. Funk, E. E. '56 and Robert H. Hardin, E. E. '54

PROFESSOR H. L. WALKER

A large majority of the top educators on the University campus are men who have had exceptional backgrounds both in industry and in education. No exception to this is Professor H. L. Walker, head of the Department of Mining and Metallurgy.

Professor Walker received his Bachelor's degree from Michigan College of Mining and Technology in 1932; his Master's in 1933; and a professional degree in 1935.

His broad experience in industry includes work as laboratory technician, research engineer, and Assistant to the Superintendent at Munising (Michigan) Paper Company; engineer for a Southern Illinois coal industry; and consultant for various metallurgical industries. During the war he was with Technical and Industrial Intelligence, and traveled to Germany. Austria, and Czechoslovakia to obtain and evaluate research on enemy industries. He was

PROFESSOR H. L. WALKER

interim Director of Mines and Minerals for the State of Illinois in 1947, and again in 1949. During the past year, he was Governor Stevenson's personal representative to investigate the West Frankfort coal mine explosion.

His experience in education began in 1932 when he was made instructor of Metallurgy Engineering at Michigan College of Mining and Technology. He held this position until 1937 when he went to Washington State College as Assistant Professor of Metallurgy and Metallography. He has been at the University of Illinois since 1938 as Assistant Professor, Associate Professor, and Professor in the Department of Mining and Metallurgy. He was made Acting Head of the Department in 1940; he has been Head of the Department since 1942.

Professor Walker's membership in eleven professional organizations is evidence of his active interest in the development and progress of his profession. He is chairman of the Peoria Chapter of the American Society for Metals; he has been a member of the executive board for the past ten years. A very active member of the American Institute of Mining and Metallurgical Engineers, he is chairman of the committee on graduate studies, and a member of the committee on student relations; program committee, and executive committee on mineral industries resarch. He was a member of he executive board of the Illinois Mining Institute from 1943 to 1945. Other organizations of which he is an active member include the American Association for the Advancement of Science, the National Society for Professional Engineers, Illinois Society for Engineers, Illinois State Academy of Science, and the American Society for Engineering Education.

Professor Walker is national President of Alpha Sigma Mu, metallurgy honorary, and a member of Sigma Xi, research honorary, and Tau Nu Tau, military fraternity.

He likes to spend his vacations on Lake Superior and in upper Michigan, where he spends his time fishing, hunting, loafing, visiting with old friends, and doing some work on a hobby of his, photography.

But speaking of hobbies, Professor Walker says his first love is his dogs. One, "Walker's Deluxe Jake," is an American Pointer. The other, "Walker's Deluxe Duke," is a Brittany Spaniel. Both are trained hunting dogs, and almost any day, in season, of course, you'll find Professor Walker and his two dogs, "Walker's Deluxe Jake" and "Walker's Deluxe Duke," roaming the countryside hunting pheasants and quail.

RICHARD SLOANE

Richard Sloan, one of our fine seniors, began his career in engineering as a pre-engineering student at Murray State Teachers College, Murray, Kentucky. He attended school there for two years, and then transferred to the University of Illinois. Here he is majoring in Mining Engineering.

Dick was born in West Frankfort, Illinois, and went to the Frankfort Community High School. He played

RICHARD SLOANE

basketball all four years of high school and football three years. One year he played football with a broken rib. In his senior year he was the Student Body President. He was awarded the Peabody Coal Scholarship.

"Face South Sloan," as his Triangle Fraternity Brothers call him, is five feet, eleven and a half inches tall, has a car, and is single. Among his hobbies are model jet racing cars, golfing, and "rifle bumming."

Richard is the president of the Mineral Industry Society, and is a Student Associate of American Institute of Mining and Metallurgical Engineers. He is a member of the Rifle Club and was the Pledge President of the Triangle Fraternity.

For the past three summers Dick has worked for the Peabody Coal Company. Last summer he did underground surveying at their Danville mine, the Oakwood Coal Company. Just recently Richard completed the oxygen breathing apparatus course of the Bureau of Mines and is now working for his first aid certificate.

As are the other seniors at this time, Richard is faced with the problem of what he will do after graduation. As of now he is planning to work for the Peabody Coal Company as a mining engineer, that is with Uncle Sam permitting.

unlimited . . .

OPPORTUNITY IN MINING

by George B. Clark, Assoc. Prof. of Min. Eng.

It is a sad fact, but nevertheless a true one, that very few of the engineering students on the campus, let alone the student body as a whole, realize that there is a curriculum in mining engineering at the University of Illinois. For the information of the readers of *Technograph*, I'd like to give a few facts concerning not only mining engineering education on the University of Illinois campus, but about the profession of mining engineering as well.

As with other groups of engineering taught at the University of Illinois, our minin engineering is recognized as being among the best there is. We are well equipped, too, with laboratories in fuel analysis, mineral dressing and coal preparation. Our mine ventilation laboratory is one of the most modern in the country, both with respect to equipment and instrumentation. One of the features of the laboratory is a new type average velocity gauge which was recently developed in the mining department. The mining curriculum is a broad one and provides the student with a well rounded engineering education as well as specialized study in mining.

The salaries for graduating mining engineers are right at the top, but in spite of this the enrollment in mining engineering has dropped (country wide) in the past two years much more, in proportion, than most of the other branches of engineering. The reason for this has not been ascertained.

Perhaps it is because of the fact that mining does not have the apparent glamour that other branches of engineering do. Or, perhaps it is because mining is considered erroneously to be an overly dangerous occupation. Whatever the reason, the number of freshmen enrolled in mining last year was about 200 for the whole United States.

This means that the demand for mining engineers during the next few years is going to be much greater, in proportion, than in other types of engineering. Right now there are three times as many jobs as there are mining engineers to fill them. And since the requirements of the mining industry for technical men is going to increase with the increasing demand for minerals and the increasing difficulty of finding and mining them, the demand for trained men will continue to grow.

Of course, it must be recognized that mining is among the hazardous occupations, but this should offer the young engineer more incentive to help solve the difficult safety problems of the mining industry. From a scientific point of view many mining problems are more difficult of solution than those in electricity, mechanics, etc., because of the many variables involved. Hence, it is a most fertile field for research and graduate study.

There are many branches of the mining profession which are open to engineers. Two of these, safety engineering and research, have already been mentioned. In addition there are the fields of mine operation, engineering design, mine administration, mine ventilation, engineering sales and teaching. Each offers an opportunity for development according to the desires and capability of the particular person concerned. The choice of location and living conditions is very extensive, including foreign service. A survey of the mining profession has shown that there are at least 30 different types of jobs which the mining profession offers, directly in mining and in closely allied industries.

A student might, among many similar questions, ask himself:

1. Do I, in addition to my ability to solve problems in mathematics, physics, chemistry, etc., like to work with the 'forces of nature" inside and outside of the laboratory More specifically, do the problems involved in learning of the forces which exist in rocks around mine openings create an interest in my mind?

2. Am I interested in the saving of human lives — lives which are needlessly given every day to produce the basic minerals we need to maintain our high standard of living

Shearing a coal seam in an Illinois mine with a coal cutter. Machines such as that illustrated have been developed as a result of extensive research in mining. (Photo courtesy of U. of I. Mining Dpt.)

3. Am I interested in academic work, teaching and research, in a new and fertile field in which there are only a score of men in the country at present who hold Ph.D. degrees?

4. Do I think I would like to work with and/or supervise the men who produce our coal, gold, silver, etc., from beneath the earth's surface

If a young prospective engineer can answer any of the above questions in the affirmative it would be well for him to further investigate the possibilities of the mining profession as a career.

by Ray Andrews, '56 and Charles LaRobadier, M. E. '55

CONFUSED KIDS

Poor little Junior, mixed-up little kid that he is, doesn't know which world to live in. Television is the evil that has forced this unsuspecting innocent into the great realms of despair and frustration that he is in today. From Space Cadet to Hop-A-Long Cassidy, the young child waivers back and forth, not knowing just which terminology to use. The complexity of this problem of the youth of today cannot be stressed too much. It can only be appreciated by actual contact with these victims of circumstances.

"Great Galloping Galaxies!" a little lad cries as he jumps from his saw horse pony. He's after Marshall Scott fer asendin' him to the interplanetary pen for a five-year stretch. Git Marshall Scott on the two-way wrist radio afor it's too late!"

"Contact! Contact!" shouts his playmate. "Hello, is that you Randolph? Just got word by pony express that Two Ray Gun Pete is acomin' to git ya!"

"Leaping rings of Saturn," comments the calm, cool, and collected Marshall. "I must take a double dose of my quick energy capsules and round up a posse to relentlessly track down this man."

Meanwhile, in a different part of the playground, Two Ray Gun and his right-hand man, Uugra, are talking—

"This sure is a rough ride, but it's worth it to git even with that no good Marshall," says villanous Two Ray. "I've sure been awaitin' fer this here chance to git him. Many's the night I paced my space cell, just awondering how I was agoin' to do it."

"Say, Boss," quips Ulgra, "how ya agoin' to do it? By the paralyzing ray, real slow, or even slower by staking him out in the desert sands to let him doe of thirst(evil laugh)."

"I thought that I might leave him in the Martian tidal zone and let him drown in the finter floods. Or I could—"

"Jumpin' horse flies! Look to the north!" yells Ulgra. "Indians ariding their vicious one-man rockets!"

"Faster! Faster!" shouts Two Ray to the driver.

But it isn't fast enough. Recess is over.

With apologies to William:

To sleep or not to sleep: that is the question:
Whether 'tis easier in body to suffer
The endless morning hours of somniferous study,
Or to rationalize, and in so doing,
Mitigate the constant plaguing of our consciences
That warns we should not, must not sleep? Ah, to sleep;
And by this wondrous, yet evasive sleep
Is ended all the countless tribulations
That seem to endlessly harass those
Who must, but somehow cannot, learn to study.
Oh, wise was he who called this sleep "a blessed thing"
But knew he full how difficult its winning?
To sleep; but then we dream: aye, there's the rub;
For in that peace which from our guiding consciences,
Was won by sheer fallacious reasoning,
We dream not of good life and lovely maidens,
But of our slide rules we have yet to slide
And of the stress and strain we have not calculated.
Then, perchance, is this the cause
That forces us to bear this vast infinity
Of work and all of its entailments,
Professors' dislike and eccentricities,
Both personal and geometrical,
Daily quizzes, hour exams and finals,
The aforesaid nights of irksome somnolence,
All of which contribute to a feeling which
Unfortunately, has no claim of panacea?
Or is it from the dread of making
Fiascos, rather than successes of our futures?
But regardless of our d i v e r s e motives,
We labor in this sea of struggle,
Perhaps, ourselves quite ignorant
Of why we persevere and strive,
Except to hold the name of scholar.

* * *

Dissertation on a Slide Rule:

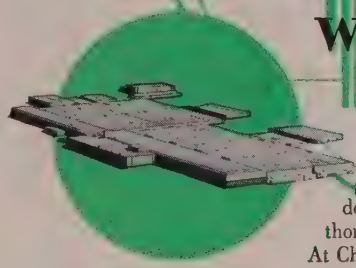
Have you ever analyzed that leather-cased instrument that hangs from your belt? Well, let's examine it for a minute.

Innocent looking thing that it is, it's really not so. First of all, it's a calculating little gadget that has a nasty habit of persistently sticking out its tongue. It delights in becoming unmanageable, especially during exams. Only at such times does it reveal a need for lubrication or adjustment. Then it demands bold-facedly, with an irritating sticking, to be powdered like a newborn babe and threatens the use of its cursor if one isn't swift about doing so. It likes to be hanging from a belt loop when it's being hunted under a chaotic pile of books on a desk.

But really it isn't so awfully bad. It stays with us—when we have it hooked to ourselves, it works for us although it's only when we push it and it gets results—like two times two is equal to three point nine, nine, nine eight.

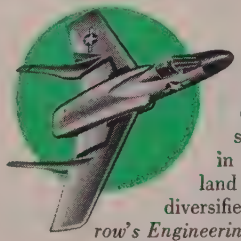
And who can deny that, in spite of himself, he becomes attached to his slip stick, if only by a snap and loop?

Greater Opportunity for the *Creative Engineer* with Chance Vought



Never before in the history of the aircraft industry has there been greater opportunity and greater demand for the young engineer with thorough training and creative ability. At Chance Vought you can join an engineering staff in one of the largest plants designed for the manufacture of military aircraft. Centered in the second largest aircraft production area in the U. S., this modern air conditioned plant is especially designed and equipped with adequate facilities for aircraft research, development and integrated production.

Security restrictions prevent a full discussion of the guided missile projects at Chance Vought, but growing requirements in all phases of development and production are creating new demands for all types of engineers and scientists. These missiles are in production for intensive experimental uses and presently are being flight tested with excellent results.



For thirty-five years Chance Vought's position in the aircraft industry has been one of pioneering and leadership. One of the latest achievements is the tailless swept wing F7U-3 "Cutlass" now in full scale production. This twin jet fighter, in the "more than 650 miles per hour category," is designed to operate from both land bases and aircraft carriers. For further information about Chance Vought and its diversified opportunities in engineering, consult a copy of our publication titled "*Tomorrow's Engineering*" now on file in your college placement library. If you are receiving a degree in Engineering, Mathematics or Physics, contact your Placement Director for an appointment with the Chance Vought Aircraft representative who will visit your campus soon.

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part two . . .

Illinois Digital Computer

edited by Hank Kalapaca, E. Ph. '53 and Ken Kolence, Physics '53

The following is the second and concluding part of an article on the Illinois Digital Computer. It involves a detailed analysis of input-output, memory, control, and power supplies, much of which was derived from a technical paper by Professors R. E. Meagher and J. P. Nash, both with the University of Illinois.

Input-Output

The input equipment consists of a photoelectric tape reader which is able to "read" the punch-coded teletypewriter tape at a rate of two feet (220 lines of punched code) per second. This is 40 times as fas as a teletypewriter operates. The input is by means of a standard 5-hole Teletype tape of which four holes are used to represent numbers in the sexadecimal or base-16 number system by means of a binary code. A 40-digit binary number is then written as a 10-digit sexadecimal number.

Output from the machine can be either to a tape punch which operates at 5 times standard teletype speed or to a teletypewriter. In either case it is in the sexadecimal system, although if it is desired the output can be programmed and converted by means of a simple routine to decimal quantities.

Memory

The memory is of the electrostatic "Williams" type using 40 *3KP1* cathode-ray tubes. Each cathode-ray tube stores 1,024 binary digits and can receive binary information from one digit of the accumulator and can release its stored information to the corresponding digit of the arithmetic, number, or order registers. Thus the total storage is 1,024 words of 40 binary digits. A slave cathode-ray tube and a 40-position switch are provided so that the contents of any one of the operating tubes can be viewed at one time. The cathode-ray tubes are operated with their deflection plates and second anodes at about 150 volts positive with respect to ground and with their cathodes at about 1,900 volts negative with respect to ground, giving an accelerating potential of about 2,050 volts.

Each cathode-ray tube is mounted in a horizontal position with its own shield consisting of a layer of copper, a layer of mu metal, and then a second layer of copper and a second layer of mu metal. Each cathode-ray tube is provided with an adjustment for intensity, focus, and astigmatism.

Associated with each memory tube is a chassis which contains a 4-tube "video" amplifier with a gain of about 50,000 for a 1.5-microsecond pulse. The chassis also contains the logical circuit to provide for regeneration in the usual way and for transfers of information to and from the appropriate registers. The output of this chassis is capacitively coupled and then d-c restored to the grid of the cathode-ray tube. The "2-dot" system of storage is used where the sensing position of the beam is called the dot and the other position is called the "dash." The beam is on for about 1.2 microseconds in the "dot" position and about 2.5 microseconds in the "dash" position. The period between cycles of memory operations has commonly been set at 22 microseconds, although all of the useful operations, including the clearing and gating of information, require about 16 microseconds.

The voltages for the deflection plates of the cathode-ray tubes which specify the position of the beam for each of the 1,024 memory addresses are obtained from an "address generator" which converts ten binary digits into 32 vertical positions and 32 horizontal positions by adding the currents from five binary stages for each. Some special care has been taken to insure that the deflection voltages are free from noise by providing special regulation for two of the voltages and by suitable limiting of the voltages on the wires which carry the ten binary digits to the "address generator."

Control

As has been mentioned the control of the Illinois machine is direct coupled and asynchronous. Rather than have an external timing device for signalling each of the operations it is to perform, it operates by having each of its operations signal the one to follow. The speed with which it operates is therefore determined by its own ability to carry out the sequencing operations which are required. Since it is direct coupled the machine will simply stop if no signal is supplied for an operation. On the other hand, the machine can be made to stop by deliberately inhibiting a signal.

(*Continued on page* 20)

Doctor James E. Robertson stands at the control panel of the Illinois computer while Gene Leichner feeds the data into the input mechanism. (All photographs and diagrams courtesy of the Digital Computer Laboratory.)

Using an electron tube developed by RCA, automotive engineers have perfected an instrument which automatically controls automobile headlights.

Out of the stars – a cure for headlight glare!

When RCA scientists developed an electron tube so sensitive that it could respond to flickering starlight, astronomers promptly put it to work in their studies of the Universe.

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COMPUTER . . .

(*Continued from page* 18)

Let us consider one flip-flop F and two operations A and B.

When F is in the 0 state, A occurs and causes F to turn to 1. This initiates B which returns F to 0, and the sequence is repeated. Thus one flip-flop can be used to sequence a pair of operations. In the same way, n flip-flops can be used to sequence 2^n operations.

There are obvious defects in the simple example just cited. In the first place, the signal from A may turn F to 1 before A has had a chance to do its work. If this happens, the enabling signal to A will disappear and A will never be completed. Secondly, B may take place while A is still on. This could have disastrous results if the two signals were related, as, for example, when A clears a register and B gates information to that register. If B gates while A is still on and, worse still, if B never gets really turned on, the information would never be gated.

In order to prevent failures of these kinds, safety circuits have been designed into the Illinois machine control. These circuits do the following things:

1. They make the turnover requirements for control flip-flops more stringent than the turnover requirements for the flip-flops being controlled. Therefore, if the latter do not turn, neither will the former, and the machine will stop.

2. They require that when a control flip-flop is being turned over and sensed, the signal from it be used only when it has been positively turned.

3. They require that before an operation in a sequence can occur the previous operation must not only have taken place but that it must also have been turned off.

Examples of circuits of these kinds may be found in the shift sequencing control. Shifting in the Illinois machine requires four operations, two clears and two gates, and these are sequenced with two flip-flops. Let us take a look at one of these flip-flops, the one which is turned over by a register gate bus. But first let us recall the register gating.

When the cathode of the gate tube is pulled down from +10 volts to −10 volts the contents of the second flip-flop will transfer if the grid was positive. Flip-flop grids are either 0 volts or negative about −20 volts. Since the cutoff of the *6J6* used for gating is about −4 volts, the gate will start to conduct when the cathode is at about +4 volts, and the transfer will have occurred by the time the cathode gets to 0 volts.

The same gate bus which pulled down the gate cathodes in the register is used to turn the control flip-flop F (Figure 4). But now the gate tube G is pegged at −5 volts instead of at 0 volts. This gives a 5-volt safety margin in the turnover of F, and it can be safely assumed that the register flip-flops turned over if F did.

Negative signals are used in nearly all of the Illinois machine control. Before F was turned, pin 6 was negative. After it is turned by G, pin 5 is negative, and one might be tempted to take the signal for the next operation from here. But this would be a mistake, for pin 5 might go far enough negative to initiate the next operation before F is

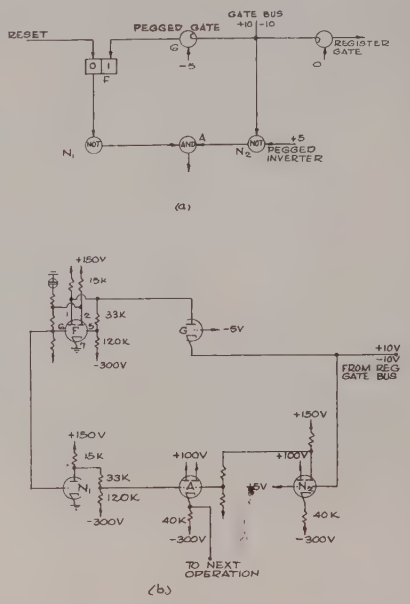


Fig. 4

safely and permanently turned over. Therefore the signal will be taken from the positive-going grid 6 which is the last moving element of F. It will be sensed with the inverter N_1 which is built just like F. Because of the cutoff properties of N_1 it will not conduct until the grid gets up to −4 volts, and by then we know that F is safely over. The output of N_1 therefore says that the register gate bus has gone down and that F has been turned over. The turnover of F will shut off the gates in the register.

We still need to know that the gate bus is back up again before proceeding with the next step. This information is obtained from the inverter N_2. With pin 5 pegged at +5 volts, the signal from N_2 will not be negative until the gate bus is safely off again. The outputs of N_1 and N_2 then go to the "and" circuit A which starts the next operation when its cathode goes negative.

This is the kind of philosophy which has prevailed in the design of the control. Throughout the control an effort has been made to assure the safe operation of each step. If any step should fail, the result is not a loss of the information in the register but merely a "hanging up" of the machine. The control waits until the proper enabling signal comes along, and then it proceeds. This kind of construction makes it possible to test the operation step by step by putting switches in appropriate places so that the turnover of flip-flops can be controlled. One such place is in the cathode of the gate turning over the flip-flop F in the previous example. If this switch is open, the register gate will not turn off and the machine will wait until the switch is closed.

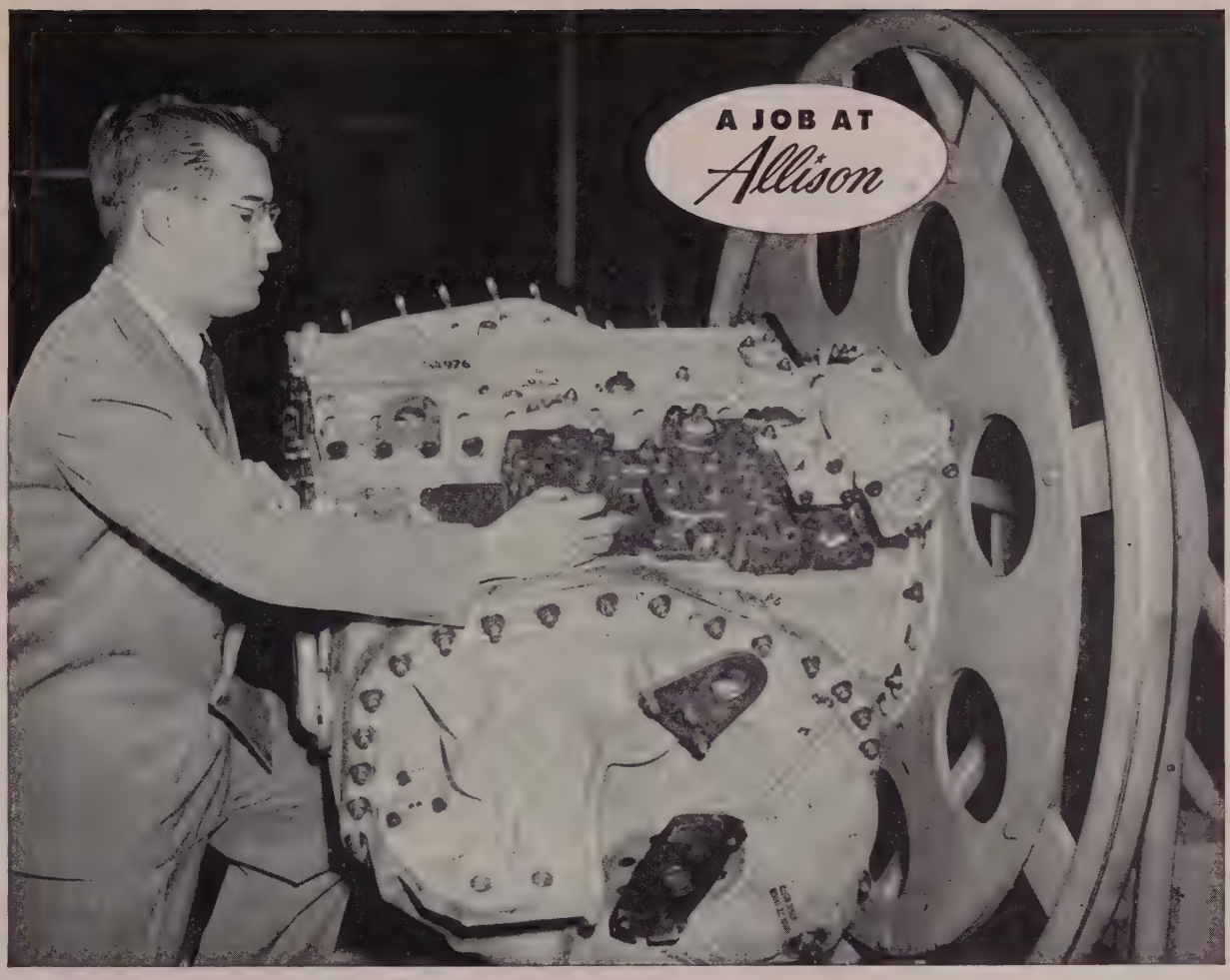
A price must be paid for these safety features, and the price, of course, is speed. The machine will run faster if it is not necessary to wait for checks on the operation. It will also run faster if operations are done as much as possible in parallel. Here again, although the Illinois machine is a parallel machine, a price has been paid in speed for convenience in doing certain control operations sequentially rather than in parallel.

The Illinois machine memory is synchronous with a period of 22 microseconds. When the control is carrying out operations which do not involve the memory, it works independently while the memory regenerates its storage locations. But if an operation requires use of the memory, the control and memory must be synchronized for one 22-microsecond interval, called an action cycle. In order to get into synchronization the control furnishes a signal to the memory. Since this signal may occur at any time during the 22-microsecond cycle, the control must then wait for an appropriate memory pulse, the action sense pulse, to come along. When this pulse comes, the action cycle normally takes place. During this cycle information is transferred to or from the memory, the necessary clearing and gating operations for these transfers being executed more or less directly by the memory pulses themselves. This one case where the memory clears and gates in the registers is the only synchronous control operation in the machine.

The action cycle ends when the next action sense pulse occurs 22 microseconds after the one which began the cycle. At this time a "have used memory" signal goes to the control to indicate that the use of the memory has been completed. The memory returns to regenerating, and the control resumes its asynchronous activity.

The synchronization process requires two flip-flops. One distinguishes between an action cycle and a regeneration cycle. The second distinguishes

(*Continued on page* 36)



● Robert F. Karcher, a 1951 Mechanical Engineering graduate from Purdue University, is another Allison engineer who is pioneering in an advanced field of mechanics. He is playing an important role in the Research and Development group of the Transmission Engineering Section.

Allison is the world's largest manufacturer of torqmatic drives for heavy-duty Ordnance and commercial vehicles and equipment. These transmissions serve a purpose far broader than a unit in the power train. All the steering and braking of the vehicle also are accomplished in the transmission. These operations are controlled by hydraulic circuits which consist of clutches, pumps, governors and necessary valving to make them operate in the proper sequence. The assembly of the valving system is often termed the "brain box" of the transmission since it determines how the transmission will operate to provide maximum performance and maneuverability with finger-tip control.

Bob, shown above examining a CD-500 transmission, is involved in developing a new improved system of governing automatic control systems of many Ordnance and commercial transmissions. This involves basic analysis, design and testing of pilot samples. These hydraulic controls provide proper sequence for clutch operation to determine speed range, convertor or lock-up operation. They also provide steering control for the vehicle when this function is included in the transmission.

Bob and other Allison engineers are continually applying their knowledge, experience and imagination to find successful answers in the never-ending search for product improvement. There is a real engineering challenge at Allison and lifetime opportunities for engineers.

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non-credit course in . . .

MINE RESCUE AND FIRST-AID

by Richard L. Sloan, Min. E. 54

The Mine Rescue and First-Aid courses are non-credit courses for anyone interested. To be eligible to wear an apparatus during a rescue operation, a physical examination must be passed. For those who do not pass the physical, they are permitted to assist in the operation from a fresh air station or from the surface.

Some of the requirements of the physical examination are as follows: (1) The applicant must have a 20/30 or better vision in each eye; (2) he must have solid front teeth, including all bicuspids. No removable bridges or plates; (3) a pulse rate is taken for a full minute while the applicant is standing and another is taken two minutes after completion of a step exercise. If the first pulse rate is exceeded by *two* beats per minute, the applicant is not considered physically fit to wear the apparatus. The course is offered from 6 o'clock to 10 o'clock one night a week for 5 weeks.

Three years ago, through the initiative of Professor R. G. Wuerker of the Mining Department, the United States Bureau of Mines of Vincennes, Indiana, furnished the first non-credit rescue course at the University of Illinois. (Two years previous to this time, a similar course was offered in the summer time for credit. Due to it being a summer course, there was little interest shown and the course was dropped from the curriculum.)

During the next two years, the State of Illinois Department of Mines and Minerals offered the course under the instruction of William J. Williams, Superintendent of the Mine Rescue Station in Springfield, with the assistance of J. J. Kotzman, Inspector at Large from Staunton, and C. S. Tartar, Superintendent of the Benld Mine Rescue Station.

The students taking the course this fall were the first group ever to be trained with the new Chemox Oxygen Breathing Apparatus. The apparatus is a self-contained breathing circuit operating independently of the outside air, employing a replaceable canister containing a chemical which, upon contact with the moisture in the exhaled breath, evolves a plentiful supply of oxygen for breathing requirements and absorbs the exhaled carbon dioxide moisture. The Chemox apparatus is equipped with an automatic timing device which rings a bell at the end of a pre-set time interval to indicate that the wearer should return to fresh air. This apparatus is illustrated by the first two men on the left of the second row in the apparatus picture.

Students of the first aid and mine rescue course. Top (from left to right) E. E. Neihaus, W. H. Stoewer, S. B. Gafvert, Philip Urso, J. J. Yancik, J. J. Kotzman, State Mine Inspector-at-Large, L. Felts, Research Assistant, University of Illinois. Center (from left to right) J. P. Snider, D. Trainor, W. H. Donley, P. A. Holtorf, O. Terichow, W. J. Williams, Superintendent of Mine Rescue Station, Instructor of the course. Bottom (from left to right) R. G. Wuerker, Assistant Professor, University of Illinois, H. Ramiros, J. Romero, R. L. Sloan, R. E. Clemons.

The McCaa apparatus has been the standard apparatus used by mine rescue teams. This apparatus is being worn by the first four men from the left on the bottom row of the apparatus picture. The instruction for this apparatus covers the different tests for tightness and tests for the working parts. Also, practice in wearing the apparatus is required. The apparatus carries a steel cylinder charged with 135 atmospheres of oxygen. The carbon dioxide is removed from the exhaled breath by Cardoxide, a highly efficient absorbent that performs this function with a minimum of heat generation. A pressure gauge is the timing device employed in the McCaa apparatus. The wearer can check to see if he has enough oxygen to continue his advancement or if he has to return to the fresh air station. Operation and care of the machine is practised throughout the course of Mine Rescue.

An apparatus not much used for mine rescue work anymore is the One-Hour Oxygen Breathing Apparatus. It works on the same principle as the McCaa apparatus but the oxygen lasts but half as long due to the capacity of the oxygen bottle and its smaller construction. It can be used in low coal seams where the McCaa would be too cumbersome. The student learns only the operation of this machine and not much time is spent on its working parts due to its similarity to the McCaa machine. This apparatus is illustrated by the third and fourth men from the left on the second row.

The Gas Mask is an apparatus that

(*Continued on page 32*)

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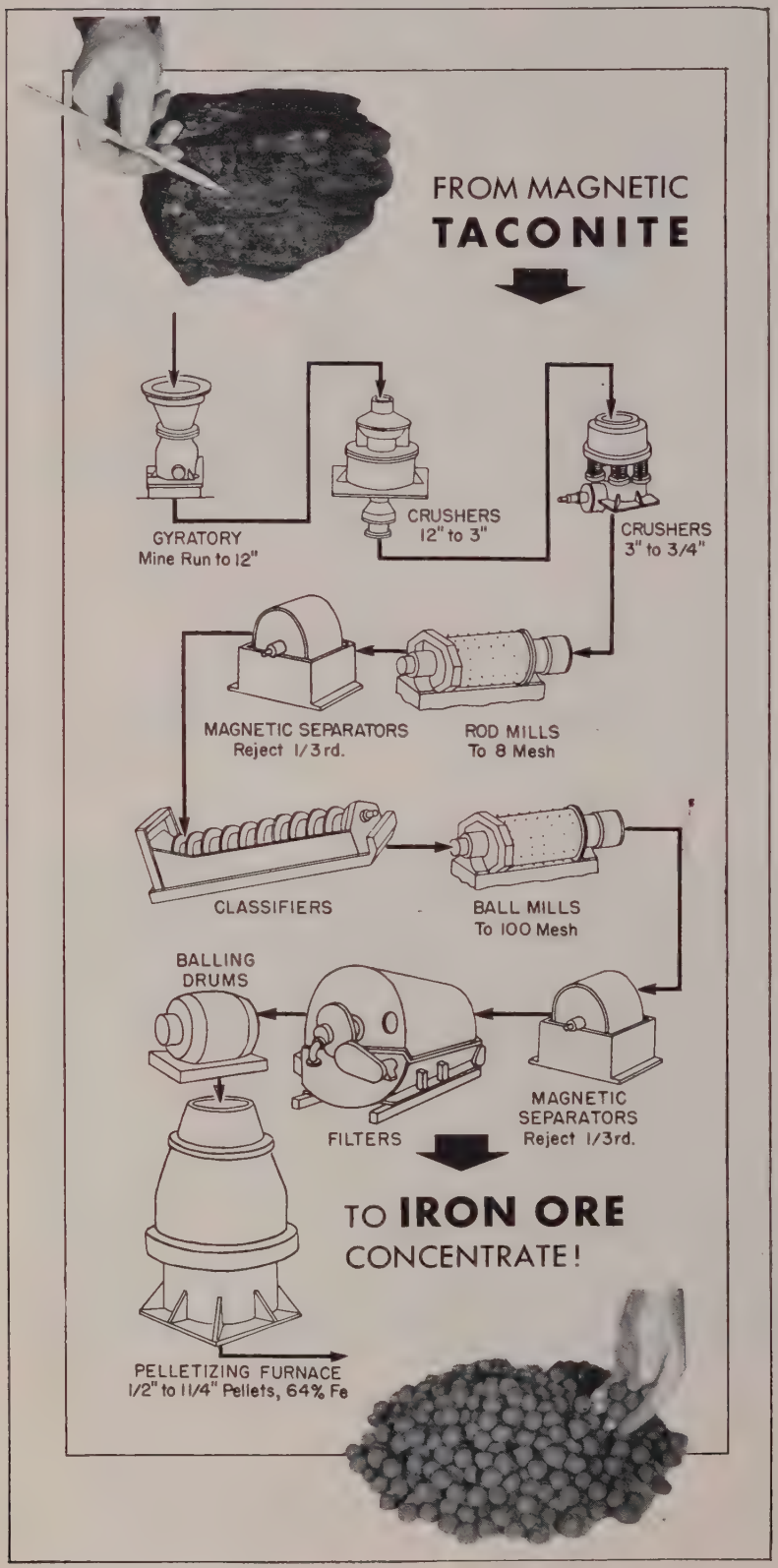


TACON

INTRODUCTION

Taconite, a word not found in most dictionaries, is a hard rock containing 25 to 35 per cent iron. Taconite deposits are now getting serious consideration because the higher grade ores left in Minnesota, Michigan, and Wisconsin are being depleted rapidly. There are bellions of tons of this rock lying on the Mesabi range in northeastern Minnesota. This area, which extends 110 miles in l ength and varies from one to three miles in width, produces over one half of the nation's iron ore. Here the greatest activity has been directed toward the concentration of the magnetic taconites. Data for future taconite plant operation is now being furnished by large pilot-plants which produce tailor-made agglomerated iron ore from the taconite rock. The reduction of the iron-bearing rock, to a form of high grade iron ore, which took nature geologic ages to accomplish, will be done in these plants through continuous process. The use of these deposits of low grade ore permits the conservation of the high grade ore so necessary in times of national emergency.

The taconite program now developed on the Mesabi Range includes five major stages: exploration, research, mining, separation, and cementing together, or agglomeration, of the powder-fine iron minerals.

I. EXPLORATION

Exploration for taconite is as much an engineering problem as mining th etaconite after it is found. Such exploration is done by drilling and is of utmost importance in the successful development of a property, as it furnishes the basis for all subsequent operations. Efficiency in exploration concerns every step in the o peration from the time a property is first considered as an exploring possibility until the last estimate is made or the property abandoned.

Prospect or exploration holes are drilled to prove out the extent and structure of known deposits of the taconite rock. The earlier exploration on the Mesabi Range was by means of trenches, test pits, and shafts. However, as the necessity for deeper and more rapid exploration arose, diamond and churn drills were brought into use. The diamond core drill, which is used

by EDWIN HUMPAL, M.E. '53, *Wisconsin Engineer*

E on the MESABI

for the hard taconite formations, penetrates rocks for a rotative cutting action producing a core for inspection and analysis. The prospect churn drill, which is used for surface drift and soft formations, penetrates rocks by percussive rather than by rotative action. A continuous flow of water, forced through hollow steel drills, flushes out drill cuttings which are delivered to settling tanks, andthen collected and analyzed.

In diamond drilling a string of hollow rods made in standard ten foot lengths, is rotated by the drill engine through a shaft and gearing. At the bottom of the line of rods is the bit, an angular ring of steel or sintered carbide in which are set the carbons of "black diamonds" which do the actual cutting. The core produced is forced into the lower rod, known as the core barrel, and is held there by a core shell and spring. When the rods are pulled up, the core and cuttings combined from a five-foot run make up the usual sample. Sampling is one of the most important steps in exploration, since it reveals the character of the formation under consideration.

II. RESEARCH

While exploration is proving out the presence and extent of the taconite deposits, research is experimenting with the material. Methods for concentration and agglomeration are developed in the research laboratory. The most feasible and economical of these methods are then tested in pilot plants. The taconite program on the Mesabi is now in the pilot plant stage. These pilot plants produce a factory-made iron ore from the hard taconite rock.

The University of Minnesota and the various mining companies are now carrying on research to find the best method to factory-make ore. The Oliver Iron Mining Division, U. S. Steel Company, is spending more than $23,000,-000 to find out how to factory-make ore at costs competitive with the ores from other domestic and foreign sources. Oliver's development work on taconite starts in the iron ore research laboratory located in Duluth and continues in the pilot plants on the Mesabi Range.

Work was started at the University of Minnesota by Dr. E. W. Davis in 1945 on finding a satisfactory method to agglomerate the taconite powder by a pelletizing process. Three years later, he had enough pellets to test in an experimental blast furnace. It is his method which is used today to produce pellets from taconite concentrates.

III. MINING

The first problem to be considered in the mining of taconite is the "stripping off" of worthless dirt and rock before the iron bearing rock is exposed for drilling and blasting. An advantage of the taconite rock over high grade ore is that it lies much closer to the surface, thus decreasing stripping costs. After the overburden is carried away, blasting is necessary to break up the taconite into chunks which can be loaded by the six to eight cubic yard power shovels used in the open pit mines.

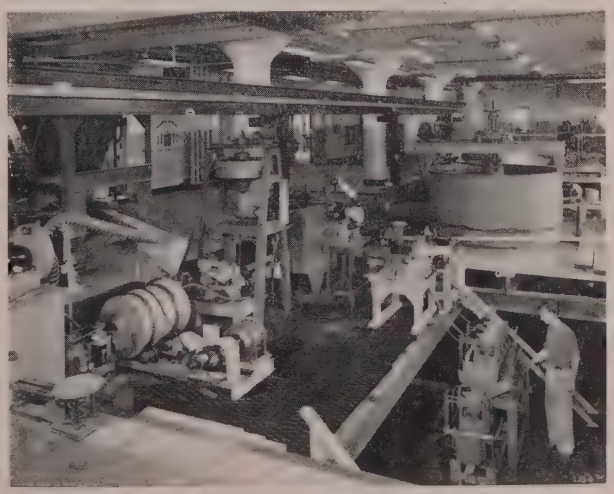
The major problem involving the mining of taconite is that of finding the most economical method of drilling primary blast holes. In these holes are placed explosive charges taconite is one of the hardest rocks on the continent, it which break up the original mass of taconite. Because requires better drilling and blasting equipment than high grade ore. Three methods of drilling the taconite are now being tested.

The oldest method used for drilling taconite is churn drilling. Unlike that of the prospect churn drill, the cutting tool is made of solid steel and is not hollow. The drill cuttings are not flushed out with water, but instead are bailed out after each few feet of drilling. The blasthole churn drill can drill holes up to nine inches in diameter by striking sharp, heavy blows with drill tools weighing more than a ton and traveling 40 inches or more per stroke. These machines are propelled by electric, gasoline, or Diesel power.

The two newer methods of drilling taconite are accomplished through the use of the Ingersoll Rand Percussion Type Air Drill and the Linde Air Products Jet Piercing Machine. In the "jet piercing" machine, kerosene and oxygen are mixed to produce an intense heat of 4500 degrees, which burns a hole through the very hardest of taconite and iron formation.

After the taconite is drilled and blasted, electric shovels, taking up to 12 tons in one bite, load it into diesel loco-

(*Continued on page* 26)



Laboratory at Duluth, Minnesota, requiring millions of dollars to manufacture millions of tons of usable iron ore.

TACONITE . . .

(*Continued from page* 25)

motives or diesel powered trucks. Conveyors belts may also be used to carry the taconite to rail loading stations on the surface. The physical characteristics of the pit usually determine which method of haulage will be most economical. The best method is then used to haul the taconite to a concentration plant.

IV. SEPARATION

Because of the low iron content in taconite, complete pulverization is necessary to gain access to the iron. This is accomplished by crushing and grinding.

The "jet piercing" machine symbolizes the spectacular experimentation found in iron mining operations. Kerosene and oxygen are mixed to produce an intense heat of about 4500 degrees. This burns a hole through the very hardest of taconite and iron formation. Powerful explosives are then inserted for blasting.

The magnetic taconite from the open pits is first brought to the gyratory crusher, where it is crushed from pit run to 12 inch chnuks. It then passes through two more crushers and enters the rod mills as material sized about ¾ inch. The rod mill crushes the orfe to a minus 8 mesh and passes into a magnetic separator. Here the magnetic ore is mixed with water and circulated through an open topped trough under a slowly moving rubber belt. Iron particles are pulled from the trough by a magnet and carried to the classifier where soluble material is carried away by water jets. The remaining ore is then routed through the ball mill where steel balls grind it to a fine powder of minus 100 mest. After it is routed to a second magnetic separator and a filter it is then ready for agglomeration. Because the fine iron oxide cannot be used or shipped economically unless it is in the form of lumbs or clinkers, several processes have been developed for agglomerating the fine powdery concentrate.

The Oliver Iron Mining Division, U. S. Steel Company, is also working with non-magnetic taconite which involves a somewhat costlier and more involved separation process. Instead of using magnets to get the iron out, it is done by "flotation." The character and nature of the mineral surface is the all-important factor which affects the flotation process. The process is essentially a chemical one and depends on the tendency of certain minerals to be selectively filmed by various chemicals and oils. The adoption of the flotation method has been held back not by the cost or lack of effectiveness of flotation separation methods, but by the lack of a cheap and effective method of pelletizing or sintering such material. With the development of such processes the flotation of non-magnetic taconites, will soon find a place in the concentration of the Mesabi Range taconites.

V. AGGLOMERATION

The agglomeration step is one of the most difficult in the taconite program because the product must retain its properties under all kinds of weather conditions, including rain, freezing, and thawing in the year round operation of taconite plants. It must be strong to withstand the severe handling on its way to the furnaces and it must have desirable physical properties in order to make furnace operation economical.

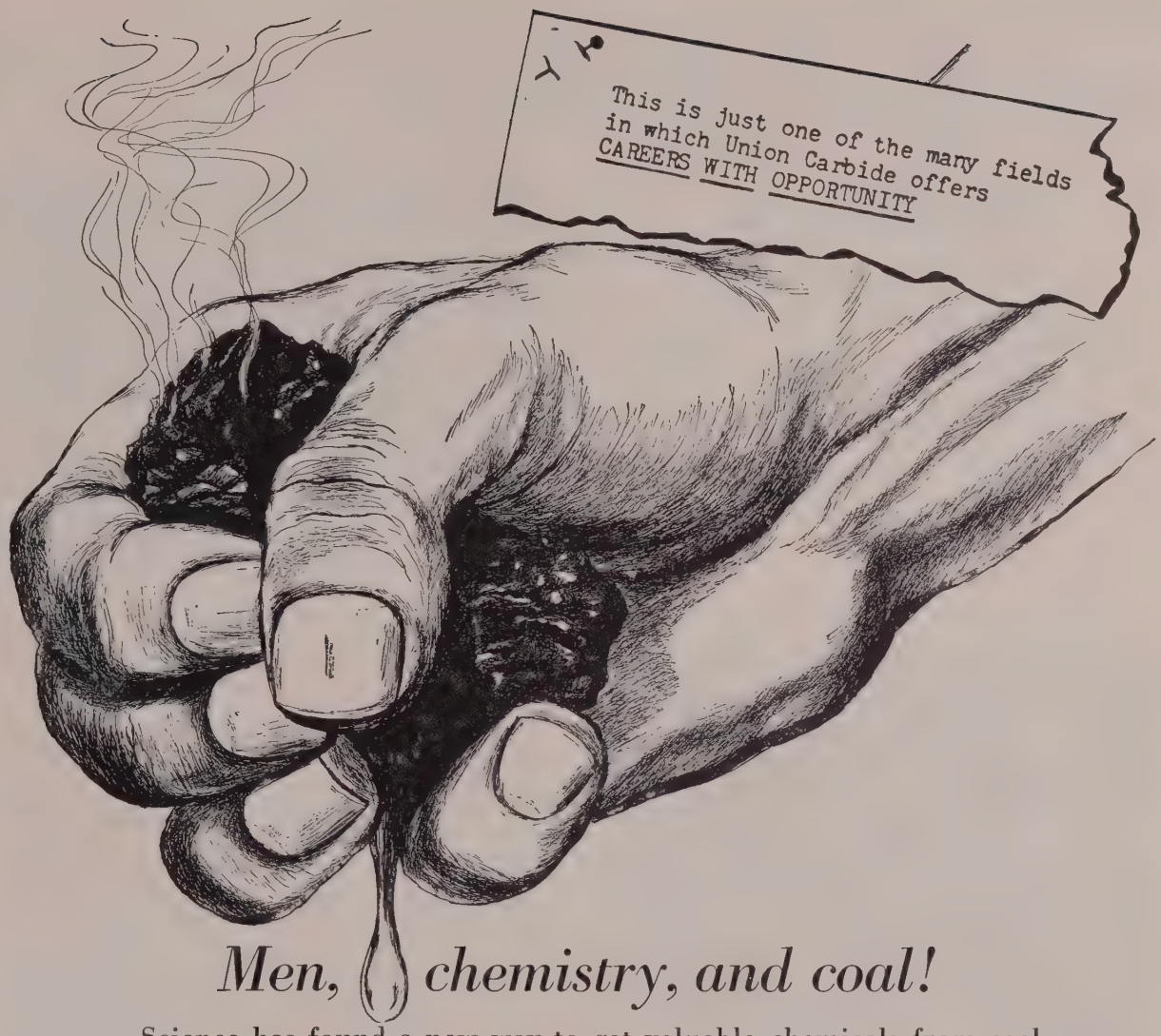
The agglomeration plant at Virginia, Minnesota, is the first experimental combination sintering and nodulizing pilot plant on the Mesabi. It has the capacity to produce approximately 500,000 tons of taconite concentrate per year. Of the three main buildings, the largest, which houses the sintering machine and the raw material section, is five stories high, 400 feet long and 60 feet wide.

During the breaking-in period, and until iron ore concentrates are available from the experimental taconite milling plant at Mountain Iron, fines from the Rochleau mine are being used in the Virginia plant. Various methods of agglomerating have been developed, such as pelletizing, briquetting, nodulizing, and sintering, but it is not yet known which one will be the most economical and make the best product for the furnaces. This plant will experiment with only two of the methods used for agglomeration in an effort to develop a method which may become part of a permanent commercial taconite plant.

In the operation of the pilot plant, fines are separated from the coarser material by a vibration screen and then carried by a conveyor to ten 750-ton capacity storage bins at the nodulizing and sintering plant. The fines, taken from the storage bins to either the sintering machine or nodulizing kiln are agglomerated into larger sized material for blast furnace use.

The sintering machine is six feet wide and 96 feet long. The fines are mixed with coke in pug mills and the material

(*Continued on page* 28)



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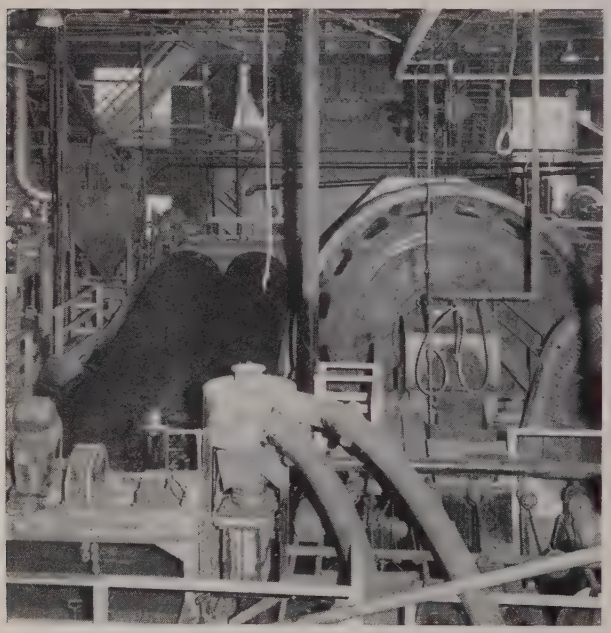
TACONITE . . .

(*Continued from page 26*)

is then fed on the slowly moving bed of the sintering machine. Here it is subjected to heat, which followed by an air blast, begins the process that fuses the mixture of coke and ore into a hot clinker-like mass. A rotary cooling bed 46 feet in diameter catches the sintered material as it comes from the machine. The red hot material is allowed to cool slowly, and then removed from the cooling bed by a mechanical rake to a loading hopper where it is transferred into railroad cars for shipment to ore loading docks.

A somewhat similar product is made in the nodulizing kiln, where a combination of heat plus the rotative action of the kiln produces egg-sized lumps of the fused fines. This brick-lined kiln, which is one of the largest in ragular use, is 12 feet in diameter and 350 feet long. The ore fines are first mixed in pug mills and fed into the end of the rotating kiln, which is heated to a high temperature by pulverized coal burners. Under heat, the ore fines form into nodules which are discharged from the kiln, cooled by an air blast, and transferred to a shipping bin for loading into railroad cars.

In addition to the quantities of ore processed, full time operation of the plant requires 50,000 tons of coke, 35,000 tons of coal, and 35,000 tons of limestone annually to produce the finished product. Oliver operates the plant on a 24-hour daily schedule, and its capacity is approximately 500,000 tons in sinter and nodules annually. The products from this experimental plant are undergoing much testing to determine their handling and shipping qualities as well as their behavior in the blast furnaces.



Erie pilot plant on the eastern Mesabi, where chunks of taconite are crushed, ground, and processed to remove impurities.

The Reserve Mining Company, with a pilot plant located at Babbitt, Minnesota, agglomerates their taconite rock by the pelletizing process. The company is also constructing a pilot plant at Beaver Bay on Lake Superior's north shore. In the operation of these plants, the water used to wash and carry the taconite through the many processes will come to about 35 billion gallons per year, and the tailings or waste sand washed away and dumped each year will amount to 95,000,000 cubic feet.

The oldest taconite plant, located at Aurora, Minnesota, and operated by the Erie Mining Company, also uses the pelletizing process for agglomerating magnetic taconite. It is capable of turning out 200,000 tons of concentrate per year and has been operating since 1948.

In the pelletizing process, the wet taconite concentrate produced by crushing, grinding, and magnetic separation is rolled into balls in a balling drum, and baked in the pelletizing furnace. This agglomeration process produces taconite pellets containing as much as 70 per cent pure iron content. Although it takes three tons of taconite to produce one ton of concentrate, the use of taconite produces 20 per cent more pig iron from a furnace than natural ores. Another advantage of the factory-made ore is that the same measure of ingredients always go into the best furnace, because the iron in every hopper of pellets can be kept uniform. This assures better production from the furnaces.

CONCLUSION

Developing the new taconite industry on the Mesabi will require huge investments in plants and equipment. Estimates vary as to how much, but it is generally agreed that it will require well over a billion dollars in new plants to equip Minnesota's taconite industry.

Up to the present, almost half-a-billion dollars has been committed to building new taconite processing plants in Minnesota. This huge sum has been invested solely by American steel businesses in this future source of "factory-made" iron ore.

Throughout World War II, and during each of the post-war years, the demand for iron and steel products has continued at high levels, carrying with it a corresponding high demand for iron ore. Steel ingot production, which reached 105 million tons last year, is expected to total 110 million this year, 118 milion in 1953 and 120 million in 1954.

To meet these increased demands for steel, it will be necessary to obtain more iron ore from South America or other foreign sources and to continue to develop the taconite and low-grade ores of the Lake Superior region.

For years the iron ore mining industry has maintained a record of dependability to the nation that remains unchallenged. The industry will continue to fulfill its responsibilities and obligations to the people of this nation by devoting all its energies toward establishing a taconite industry on a sound, firm basis.

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ACKNOWLEDGEMENTS

The Public Relations Department of the Oliver Iron Mining Division, U. S. Steel Company, located at Duluth, Minnesota.

The Electric Machinery Mfg. Company, Minneapolis, Minnesota.

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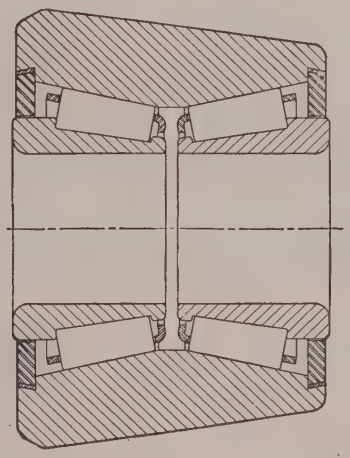

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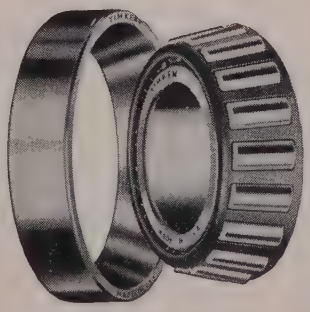

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MINE RESCUE . . .

(*Continued from page* 22)

used beyond its normal life might be dangerous and there have been fatal results. It is emphasized in this course that the gas mask should be used only where a flame safety lamp will not be extinguished. The M.S.A. All-Service Gas Mask is the only gas mask permitted by the United States Bureau of Mines during rescue and recovery work. The main test demonstrated in class is air tightness. The Gas Mask is being worn by the fifth and sixth men from the left in row two. The Gas Mask and flame safety lamp is shown by the first man on the left on the bottom row.

Each man in the class is trained with all of the above apparatuses using a life line and a horn signal as would be used in actual rescue cases. The life line is a rope on a reel that is placed at a fresh air station. Each member of the rescue team, which usually consists of five men, holds on to the rope as they advance through the mine. At no time do they let go of the line for it is their only means of communication with the outside. The captain leads the men by a system of signals made by a small hand horn. He communicates with the outside by a system of jerks on the rope.

At the completion of the course, an oral examination is given by W. W. Kessler, Federal Inspector for District VIII of the United States Bureau of Mines, Vincennes, Indiana. Those completing the course receive a pocket-size card and a certificate from the State of Illinois Department of Mines and Minerals and from the United States Bureau of Mines.

FIRST-AID

The first-aid section is offered after the Rescue course has been completed. This fall semester, there were two women enrolled. They are wives of two mining students. This course is offered from six o'clock to ten o'clock on Monday nights for five weeks.

There are six fundamentals taught in this course. These fundamentals are:

1) Artificial Respiration.
2) Control of Bleeding.
3) Care of Physical Shock Victims.
4) Care of Wounds and Burns.
5) Care of Fractures and Dislocations.
6) Transportation of the victim.

Three types of artificial respiration are taught and practised during the entirety of the course. These are the Shaefer, Sylvester, and the new push-pull type called the Eilson. Emphasis is placed on the continuation of artificial respiration after it has once been started. There has been cases where a person revived after 72 hours of application. The conditions that warrant artificial respiration are: electric shock, gas poisoning, drowning and suffocation.

The eleven pressure points on the body that check arterial bleeding is the first principle taught in the second fundamental, control of bleeding. Along with the pressure points, the application of tourniquets and bandages is discussed and practiced by the class.

Physical shock accompanies all forms of injuries. Due to physical shock being the cause of a great portion of deaths after injury, the instructor, during every lecture, asks different students the cause, symptoms, and treatment of physical shock so that no student will forget the importance in knowing all there is to know about it.

The care of wounds and burns is the fourth fundamental taught. The care for abrasion, incised wounds, lacerated wounds, and punctured wounds are the topics discussed in this section. Also, the care of the three different degrees of burns and how to bandage these wounds is practiced.

The different types of splints and pressure bandages are taught and practiced in the section on dislocation and fractures. During this study, the care and position of the patient is exercised.

Transportation is the last of the fundamentals of first-aid, but it is in no sense of minor importance. To make one mistake in transporting a patient could cause agitation to the injury and the severity of it could be fatal. A case was cited where a stretcher crew did not check the stretcher to see if it were strong enough to haul the injured person, who had eight broken ribs. When the men lifted the victim, the stretcher was rotten and the man fell to the ground. Two weeks later, the man died. The class is taught how to make an improvised stretcher in case the stretcher to be used is found to be defective. To prevent jarring and swaying of the person during transportation, the class practices a walking pace that checks undue movement of the victim.

Again at the completion of the course, Mr. Kessler gives an oral examination over what was covered. Certificates and pocket-size cards are received by the members of the class from the State and Department of the Interior as before.

To know first-aid is to be one step ahead of death or deformity. Anyone interested in this course should contact Professor R. G. Wuerker of the Mining Department for the course next fall. Remember—THE LIFE YOU SAVE, MAY BE YOUR OWN.

JOY CONTINUOUS . . .

(*Continued from page* 9)

the beam-supported section of the room and well clear of the ripper head as it advances into the unsupported section. There are two built-in timbering jacks, one on each side of the main chassis, as both a safety factor and an aid in timbering operations.

The main chassis receives the coal from the ripper head assembly in its central hopper. From there it is taken by the intermediate conveyer back to the rear conveyer which in turn transfers it to shuttle cars or mobile conveyer units.

A turning radius of forty-five degrees on each side of the main center line and an elevation capability of fifty-nine inches above the baseline allows the rear conveyer to multiply the radius where the continuous miner can work and still be reached by shuttle and conveyer units.

The Joy Continuous Miner with its auxiliaries — the shuttle car and the mobile conveyer belt — have started a new method of mining which has revolutionized the coal mining industry. This machine — well capable of timbering, making entries, working rooms, taking pillars and split seams and loading, in short completely eliminating the former separate jobs of cutting, drilling, shooting and loading out — has turned coal mining into a highly skilled mechanical operation, where the laborer is replaced by the machine operator.

Safety is greatly increased and cost just as greatly reduced. Only one comparatively limited area, requiring no trackage, must be ventilated, maintined, supervised and supplied with power. When an area is mined out the pillars are retreated and the area is abandoned completely. With no mined out areas and with the working area considerably reduced, the usual heavy cost of ventilating, pumping and general maintenance of these areas is removed, increasing profits considerably.

The continuous miner is finding uses in other kinds of mines besides coal. J.C.M. units are in operation in Borax mines in Colorado and in Potash mines in the Southwest and France. More are being tried in other types of mines. The limit of versatility of these machines has yet to be found.

The farmer was sitting on his front steps eating a sandwich when a hen zoomed by with a rooster in hot pursuit. Suddenly the rooster put on the brakes, slid to a halt, and began picking up the crumbs from the sandwich.

"Dern," muttered the farmer in disgust, "hope I never get that hungry."

Takes a lot to lay a carpet in the jungle

The scene is "darkest Africa".

But Africa is lightening. Man's quest for minerals, for new areas for agriculture and trade, is slashing ultra-modern, glaring-white air strips in once impenetrable jungle.

Those pavers, portable air compressors, pumps and air tools—such as you might see working a city street—are Worthington Blue Brutes going to "lay a carpet" in that hole in the jungle.

Thus, Worthington, a major producer of equipment for public works, industry and farm, brings the fruits of American technical genius to the strange places of the world.

And illustrates, too, how the unique American talent of *diversification* helps public, employees and stockholders. For Worthington makes many things—not just construction equipment and pumps, but also engines, water works machinery, power transmission, petroleum equipment, air conditioning and refrigeration, many others.

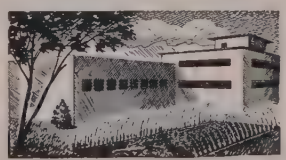
Such diversification builds *stability* . . . makes Worthington, 112 years old, a strong link in the chain of American business.

Worthington Corporation, formerly Worthington Pump and Machinery Corporation, Harrison, New Jersey.

WORTHINGTON

The Sign of Value Around the World

1.14



Good Water and Sanitation—engines pumps • water treatment • comminutors air compressors • air tools

Lower-Cost Manufacturing—pumps compressors • steam turbines • motors power transmission • air conditioning

Petroleum Products—compressors engines • pumps • chilling equipment refrigeration • decoking systems

More Abundant Food—compressors fertilizer mixers • air conditioning refrigeration • pumps

COMPUTER . . .

(*Continued from page* 20)

between the time before the action cycle, when the memory is still regenerating, and the time afterward when it has returned to regenerating but while the "have used memory" signal is on.

A large part of the control is devoted to setting up the proper clear and gate sequences for the registers. Fundamentally, of course, everything that is done in the arithmetic unit must be a combination of sensing flip-flops, adding, clearing, and gating. The decisions about these things are made after certain combinations of digits, called orders, have been decoded with logical circuits. The number of orders that is actually necessary for the convenient coding of the kinds of problems which the Illinois machine is expected to solve is probably between 20 and 30, and this many orders can be described with 15 flip-flops, ten of them being needed for memory addresses. A decoding matrix using five flip-flops would then be used to cause one of 32 wires to be actuated whenever the corresponding order is presented. However, since there are 20 digits available for an order of which only ten are needed to describe the 1,024-memory locations, we can use as many as ten for an instruction. Actually eight have been used with the result that the number of tubes required for decoding has been decreased and the number of orders has been increased. The number of orders which has actually been used in programming is about 50, some of which were not forseen when the control was designed. A complete matrix is not used, the decoding circuits being made up of a number of submatrices.

The arithmetic of the machine is one which handles numbers in the range from -1 to $+1$ (actually excluding $+1$) and which carries negative numbers as complements relative to 2. In particular, the method by which multiplication is carried out is not used, as far as we know, in any other machine. (This method was suggested by Mr. J. E. Robertson of the University of Illinois.)

Multiplication without roundoff by two positive numbers poses no problems. If an operand x is negative, the machine holds the number $2+x$, and if the sign digit of x is ignored multiplication by a positive y gives the result $xy+y$ so that subtraction of y will give the desired answer. If x is the multiplier, there is no difficulty because y is available at the end and can be subtracted. But if x is the multiplicand, y is lost during the process of shifting to inspect its digits. Hence it must be subtracted during the stepwise formation of the partial products.

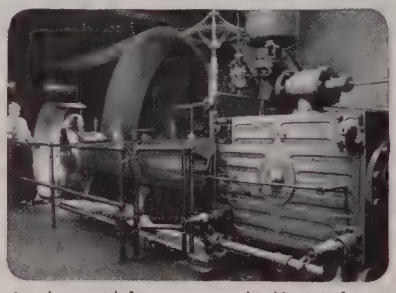
The Illinois machine multiplication scheme makes no distinction between positive and negative multiplicands. This is accomplished by making an algebraically correct division by two at each step, and always adding the complete multiplicand with its sign if an addition is required. No corrections are required at the end. The same circuits are used as those which carry out the right shift order, this order giving a correct division by 2 in the accumulator.

The problem posed by the roundoff, which requires that the product be rounded to a sign and 39 places after the addition of 2^{-40}, has been solved by doing the roundoff before the multiplication begins. If there is no roundoff, the accumulator is cleared and the product xy is formed. If there is to be a roundoff, the accumulator is cleared, 2^{-1} is gated into it, and the quantity $xy+2^{-40}$ is formed. Since the accumulator holds only the sign and first 39 digits of the product, it holds the rounded product.

This method of rounding off has the advantage of being fast, because there is no need to do an additional step at the end which involves waiting for carries in the adder, and it also provides the facility for gating the digit 2^{-1}, into the accumulator for other orders.

(*Continued on page* 40)

Demonstrating the Dependability of FRICK Equipment



The portable steam engine shown at left was operated in Virginia from 1872 to 1949: the Corliss type above, built in 1891, is still running at Irwin, Penna. Another Frick Corliss, shipped in 1888, is still going strong at Weldon, N. C.

Frick Company was established a century ago for making engines and farm machinery. For over 70 years it has pioneered in building refrigerating and air conditioning systems. Frick compressors commonly achieve service records of 40 years; many have run 50; some even 60!

This portable engine still runs after 72 years' active service.

The whole story of Frick equipment is told, with 200 illustrations, in the Centennial History just published: send $1 for your copy.

The largest Frick refrigerating machine ever built (1896), was 50 ft. long: in service for Armour 40 years.

The Frick Graduate Training Course in Refrigeration and Air Conditioning, operated over 30 years, offers a career in a growing industry.

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Also Builders of Power Farming and Sawmill Machinery

MATERIALS-HANDLING EQUIPMENT
THAT SPEEDS WORK, SPARES MEN, SLASHES COSTS

No other Mobile Crane of this type has all the features of ***KRANE KAR***. More goes into ***KRANE KAR*** . . . you get more out of ***KRANE KAR*** . . . more speed, more work, more safety. Loads and Unloads freight cars, trucks, trailers . . . Stacks and Stores . . . expedites Plant Maintenance.

KRANE KAR handles steel stock and forms of any shape or size within capacity (or scrap when equipped with magnet); transmission cases, motors, crankcases, transformers, etc. Works in tight quarters, low headroom, up and down ramps . . . anywhere, in plant or yard. Often cuts handling costs to 8¢ a ton.*

Safest Crane in its class, minimizing injury risks to men, materials, machine. ***Self-Stabilizing:*** dangerous use of jacks or stabilizers eliminated. ***Automatic Power Cut-Off*** at extreme positions of Boom-Swing or Topping. ***Automatic Braking*** of Load and Boom Lines. ***No Tail-Swing:*** no part of Crane passes over operator's head.

Gas or Diesel. 9 to 37 ft. booms or adjustable telescopic booms; Electric magnet, clamshell bucket, and other accessories available. Ask for illustrated bulletin #79.

USERS: General Motors; Bethlehem Steel; Todd Shipyards; Boeing; General Electric; duPont; Pullman Standard; etc.

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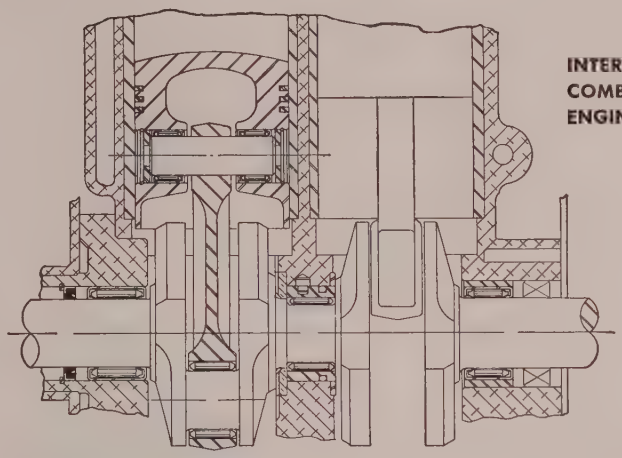
The Torrington Needle Bearing...

for designs where light weight is important

Reducing weight without sacrificing performance is one of the major considerations in many modern products. Designs are streamlined to pare off excess weight. New and lighter materials are being used. Components which save even a few ounces frequently contribute greatly to product success.



Needle Bearings reduce weight and size while providing high radial load capacity.

Light Weight Plus High Capacity

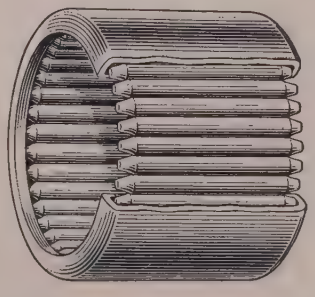
The unique design of the Torrington Needle Bearing makes it ideal for a wide variety of product uses. It consists of two components — a thin, hardened outer shell and a full complement of small diameter rollers. Its many lines of contact give the Needle Bearing a greater rated radial load capacity than any other type of anti-friction bearing for its size and weight. Conversely, for a given load capacity, a Needle Bearing is the lightest, most compact bearing available.

Weight Savings In Related Assemblies

In addition to the light weight of the Needle Bearing, its design permits sizable reductions in the size and weight of the related assemblies. Its small outside diameter allows the use of smaller housings. And, since a press fit in a simple straight housing bore is adequate to locate the bearing, no complex shoulders or housing modifications are required. The hardened shaft usually serves as the inner race, saving additional space and weight.

These advantages, plus its high radial capacity, have made the Torrington Needle Bearing particularly attractive to the designers of aircraft, portable power tools, small gasoline engines and many other products where weight and space are important factors.

In future advertisements of this series, other features of Torrington Needle Bearings will be discussed. The new Needle Bearing catalog will be sent on request.



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TORRINGTON *NEEDLE* BEARINGS

NEEDLE • SPHERICAL ROLLER • TAPERED ROLLER • STRAIGHT ROLLER • BALL • NEEDLE ROLLERS

COMPUTER . . .

(*Continued from page* 36)

In connection with a shift order a digit can be put any place in the accumulator without requiring additional memory storage space.

Power Supplies

The machine uses about 8.8 kw of a-c power to operate the filaments of the vacuum tubes.

The d-c power consumption is:

—2,000 volts	0.08	ampere
— 300 volts	15.7	amperes
+ 100 volts	11.0	amperes
+ 150 volts	3.2	amperes
+ 300 volts	6.4	amperes
+ 680 volts	0.35	ampere

The —2,000-volt and the +680-volt potentials are obtained from vacuum tube regulated power supplies which were built at the University of Illinois.

The intermediate four voltages supply the bulk of the d-c power for the machine and insofar as possible all circuits have been designed to use these voltages directly without additional regulation or "bleeders." In a few cases such as adder circuits "odd" voltages are required and these are furnished by a "bleeder" which supplies voltages for vacuum tube grids where the current drain is very low. These four "main" voltages are furnished by commercially built and controlled rectifier units which are regulated against line voltage changes and fast and slow load changes to ±2 per cent.

All of the d-c loads are divided into separate circuits of about 3 amperes each and arranged with individual fuses in such a way that the failure of any individual circuit will open a relay thus turning off a "holding circuit" on all of the d-c power.

Conclusion

A variety of complex problems have already been solved on the Illinois computer. A few of them are: Analysis of structures by members of the Civil Engineering Department, investigation of rubber molecules for the Chemistry Department, statistical analysis of data for the Psychology Department, numerical solution of sets of differential equations, and calculation of 20,000 decimal digits of e. Judging from the work accomplished by the computer thus far it seems safe to conclude that the Illinois machine will prove to be a valuable tool in all phases of University research.

"Use Lump-O-Soap. Doesn't lather. Doesn't bubble. Doesn't clean. It's just company in the tub."

MINING . . .

(*Continued from page* 11)

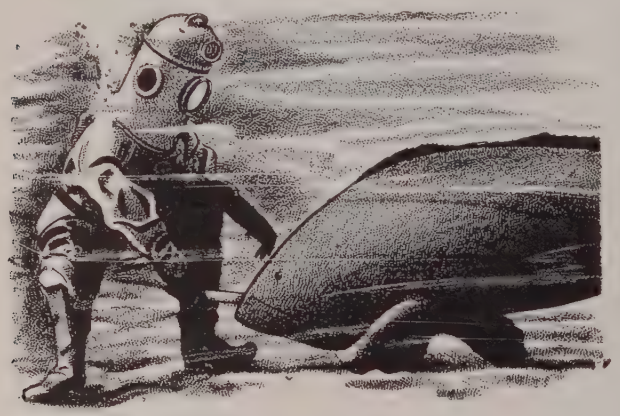
background so that he may intelligently carry on work in any of the special fields.

Freshmen and sophomores in metallurgical engineering take basic courses in chemistry, physics, math, drawing and rhetoric. During the junior year they take up physical chemistry, principles of physical metallurgy, metallurgical calculations, pyrometry, ferrous metallography, electrometallurgy and resistance of materials. The senior year takes up elements of electrical engineering, nonferrous metallography and metallurgy, advanced materials testing, advanced physical metallurgy, alloy steels, and the metallurgy of deep drawing and pressing.

Mining engineering is concerned with the removal of useful materials from the earth's crust. It consists largely of the application of principles of geology and of civil, mechanical, electrical and chemical engineering to the discovery, exploration, development and extraction from the earth of economically valuable materials.

Several branches of mining offer opportunities to engineers. Coal mining has a profound effect on our national

(*Continued on page* 44)



The wonders of the ocean's floor are duplicated in two giant tanks at Marine Studios, at Marineland, Fla. More than 30,000 live undersea specimens are presented in their natural setting, and into these tanks are pumped more than 7,000,000 gallons of sea water per day.

Okolite-Okoprene cable was selected as the most reliable means of supplying power to the motors which pump this water. Power is taken from a 2300-volt circuit and stepped down to 220-110 volts, for motors ranging from ¼ to 30 h.p.

The corrosive influence of salt water and salt air has virtually no effect on the tough Okoprene sheath which protects Okolite-Okoprene cable.

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Tough jobs are the true test of electrical cable . . . and installations on such jobs usually turn out to be Okonite.

OKONITE *insulated wires and cables*

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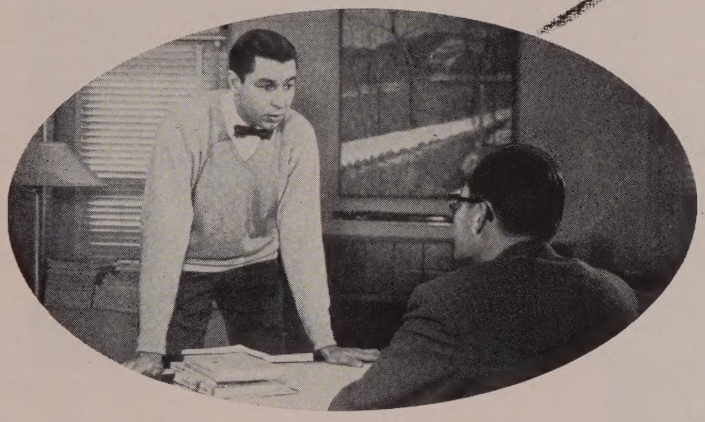
an AIRCRAFT engineer?

But I haven't majored in aeronautical engineering

That doesn't matter. Lockheed can train you... at full pay!



It's your aptitude, your knowledge of engineering principles, your degree in engineering that count.

Those—plus the opportunity Lockheed is offering you—are all you need for a career as an aircraft engineer. In Lockheed's special program for engineering graduates, you may go back to school, or you may convert to aircraft work by doing—on-the-job training. But whichever it is, you receive full pay while learning.

But Lockheed offers you more than a career. It offers you a new life, in an area where living conditions are beyond compare. Outdoor living prevails the year-'round. Mountains, beaches are an hour from Lockheed.

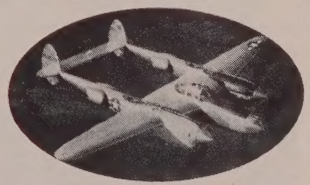
See your Placement Officer today for the details on Lockheed's Aircraft Training Program for engineers, as well as the better living conditions in Southern California.

If your Placement Officer is out of the illustrated brochures describing living and working conditions at Lockheed, write M. V. Mattson, Employment Manager.

Lockheed Aircraft Corporation

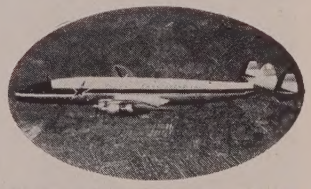
Burbank, California

This Plane made History



The P-38 Lightning – first 400 mile per hour fighter-interceptor, the "fork-tailed Devil" that helped win World War II.

This Plane is making History



The Super Constellation – larger, faster, more powerful; the plane that bridges the gap between modern air transport and commercial jet transport.

This Plane will make History

The jet of the future—the plane you will help create—belongs here.

This plane – which exists only in the brain of an engineer like yourself – is one reason there's a better future for you at Lockheed. For Lockheed will always need engineers with ideas, engineers with imagination, engineers who build the planes that make history.

MINING . . .

(*Continued from page* 40)

economy. The United States has more than 50% of the world's known coal reserves. Metallic mining refers to the mining of such metals as copper, gold, silver and zinc. Non-metallic mining takes in the mining of such minerals as potash, limestone, silica, and sand. Also, a tremendous field is opening up in mine research. Much information about explosives, the physical properties of rocks, and mine safety problems is vitally need today.

The curriculum in mining engineering is designed to give the student instruction in fundamental problems of mining engineering, as well as to provide a broad background in engineering as a whole. Freshman and sophomores in mining take about the same basic courses as do underclassmen in metallurgy. They also receive instruction in geology, fuels, and elements of mining. In the junior year courses are given in surveying, economics, electrical engineering, fluid mechanics, dynamics, and resistance of materials. The senior year covers mine administration, mining methods, mineral dressing, mine haulage, hoisting, and pumping, the geophysics of mining, engineering metallurgy, mine examination and valuation, mining design, coal preparation, and mine ventilation.

Since the number of men graduating with degrees in mining or metallurgical engineering is small, and the demand for these men is great, job opportunities are very good in both fields. Metallurgists can be found in research, development, or as part of management in various capacities such as the director of a laboratory for control of quality, a director of research, or a superintendent of heat treatment. In addition, every business which is concerned with the production, processing, or use of metals and alloys is finding it more and more difficult to remain successfully competitive without the services of a metallurgist. This realization of the part of industry is creating many new positions for metallurgical engineers.

The mining engineer may find his life's work in any one of several aspects of mining. Mining administration, practical mining engineering, mine examination, consulting engineering, fuel technoloy, mining geology, mining sales and research are some of the avenues open to him.

A mining or metallurgical engineer must have a genuine interest in things that engineers do, such as mathematical analysis, design, research, and development. He must have the ability to think logically, a willingness to work hard, the ability to cooperate with others, and the capacity to assume leadership. If a student possesses these qualities *plus* a great interest in mining and metallurgy, he will never regret having chosen mining or metallurgical engineering as his life's work.

● For many years K&E has pioneered in the manufacture and development of finest quality surveying instruments. K&E surveying instruments are renowned all over the world for their superb performance under conditions of all kinds, for their magnificent workmanship and for special features that come of progressive ingenuity.

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MINERAL INDUSTRIES SOCIETY

The Mineral Industries Society started off this semester with its annual smoker which was held at the Illini Union on October 8. The purpose of this meeting was to acquaint the freshman and transfer students with the members of the society and to offer them an opportunity to meet their instructors on an informal basis.

This meeting was followed by the first business meeting of the year which was held on November 12. The following men took over as officers for the fall semester: Richard L. Sloan, president; Wilford Couts, vice president; Warren Holland, secretary; William Stoewer, treasurer. D. R. Chedsey will continue to serve as faculty advisor. the society's monthly meetings include either a lecture or a movie which is of interest to both the Mining and Metallurgical students.

One of the society's annual events is a softball game held every spring between the Metallurgy students and Mining students for a fur-lined chamber pot.

WHITE PINE . . .

(*Continued from page* 13)

on slight grades above the roadways.

Considerable effort was necessary to design a dwelling unit that was functional and yet in keeping with the moderate cost to provide such a unit. It is a credit to the architectural skill of PACE Associates that they have achieved such a unit and made it available in a variety of forms and methods of placing to avoid the all too common "mining town" appearance. They have provided one and two bedroom dwelling units so arranged in the over-all townsite plan that no two identical dwelling units are adjacent to each other. The initial plan calls for the construction of ninety dwelling units with an additional fifty units to be under construction upon completion of the initial order. The first units were commenced in August, 1952, and construction has approximated a production line basis ever since.

A tentative plan calls for the construction of a series of prefabricated type dwellings, again to inject variety into the over-all layout, and several homes of this form are being investi-

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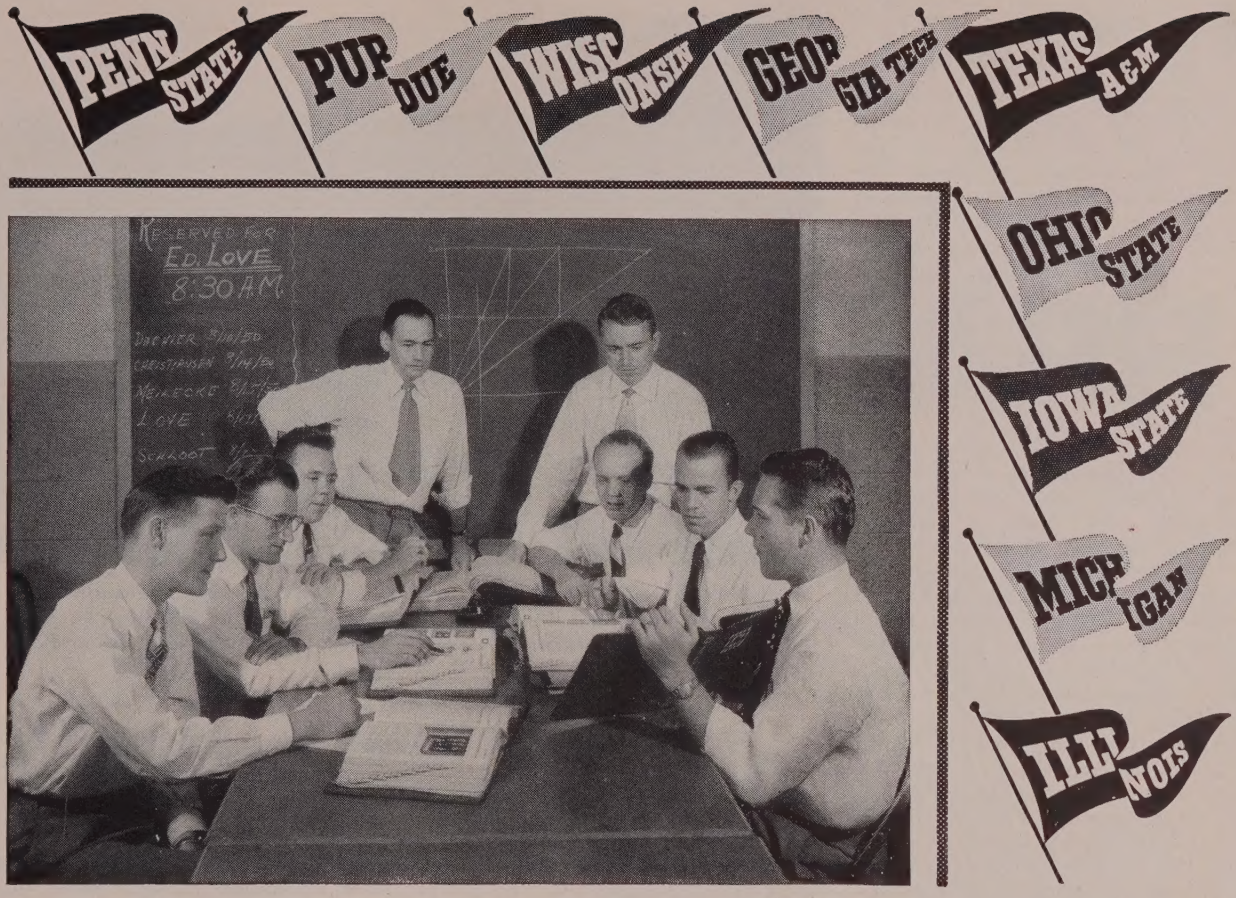

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● Year after year, Square D looks to the schools indicated above for electrical, mechanical, general and industrial engineers. We need a lot of such talent in our job of designing, producing and distributing a broad range of electrical equipment.

If you are looking for a future with real opportunities for growth and advancement, Square D has much to offer. You'll get *sound, thorough* training. Square D is big enough to be a leader in its field... but not too big to give *individual* direction to its men. And of real importance—you'll be entering a field which is basically sound and constantly expanding. Worth thinking about, isn't it?

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We'd like to send you a 16-page "get-acquainted" brochure. It tells a lot about Square D, its products, services, markets and opportunities.

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Square D's "Get-Acquainted" brochure.

Name_____

School_____ Class_____

Address_____

City_____ Zone_____ State_____

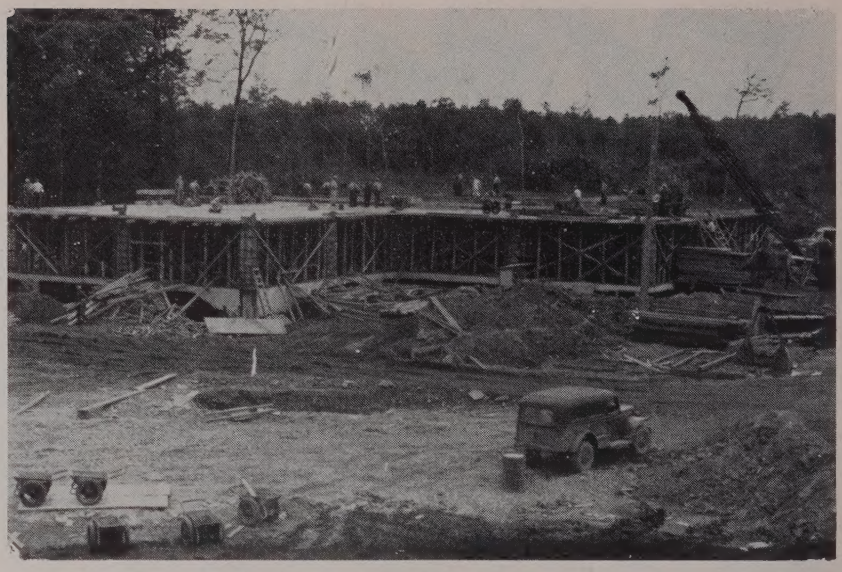
SQUARE D COMPANY

WHITE PINE . . .

(*Continued from page* 44)

gated. It is not too remote to believe that most every modern type of dwelling unit will find its way into the White Pine townsite to permit the townspeople to express their preferences for the type of house that suits their fancies. This all in contrast to the frame, clapboard dwellings found in abundance in the range towns northeast of White Pine and out in the western United States. It is not difficult to appreciate the problems of furnishing a variety of dwelling plans all within the prescribed cost.

To ship the metallic copper to the eastern industrial centers a railroad has been constructed into White Pine from the nearby resort town of Bergland, Michigan, ten miles to the south. The Duluth, South Shore and Atlantic Railroad main line from Duluth to the Soo runs through Bergland and the White Pine spur leaves the main line near the shore of beautiful Lake Geogebic, probably the largest inland lake in the Upper Peninsula. The original rail line into White Pine came from Ontonagon along the southern shore of Lake Superior from a connection with the Chicago, Milwaukee, St. Paul and Pacific Railroad. It was not feasible to reconstruct this track as the harbor at Ontonagon will not accommodate large coal vessels and hauling coal by rail via Bergland was found to be more economical. Also the Ontonagon route would require the bridging of many small streams which drain into Lake Superior.



Preparing to pour the roof slab on the White Pine hospital. Designed by PACE Associates and built by the Turner Construction Co., this hospital will be the most modern structure of its type in Michigan's Upper Peninsula.

Electrical energy to drive the machines in the process buildings, and to light the White Pine homes is provided by a special line of the Upper Peninsula Power Company from the hydroelectric plant at Victoria dam, seventeen miles to the east. This monumental structure, over one hundred feet high, was one of the first of the gravity-arch dams in the United States. Behind the dam is jewel-like Victoria Lake, a popular fishing spot.

Besides residing in one of the newest towns in the country, White Pine townspeople will have the advantages of a delightful summer climate, close proximity to the famed Porcupine Mountains State Park, opportunities for deep sea fishing in Lake Superior, and hunting for many kinds of game animals that abound in this region. During the construction of the townsite last summer, wild deer and bear were common visitors. Many porcupines and smaller animals are also at hand for nature study.

It has been some time since a town was constructed out of the wilderness, especially in the Middle West. But White Pine is evidence of the pioneering spirit that would make any of our founding fathers proud. The difference between White Pine and the older Middle Western town is engineered progress. White Pine has been engineered and planned for the people and purposes it is to serve. With such a foundation, who can foretell anything but success for America's newest town—White Pine, Michigan.

Excavation for the mine portal in the White Pine works area. This portal leads, on a gentle slope, into the mine shaft. Initial crushing of the copper ore will be done in a building located in the portal to avoid haulage of waste rock.

A man died and left $100 each to an Englishman, an Irishman and a Scotsman, on condition that they each put $10 in his coffin.

The Englishman dropped in his $10, and the Irishman did likewise. Then along came the Scotsman who put in the coffin a check for $30 and took out the $20.